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Solar Absorptance and Thermal Emittance of Some Common Spacecraft Thermal-Control Coatings

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Solar Absorptance and Thermal Emittance of Some Common Spacecraft Thermal-Control Coatings

John H. Henninger

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and Space Administration

Scientific and Technical Information Branch

All measurement values are expressed in the International System of Units (SI) in accordance with NASA Policy Directive 2220.4, paragraph 4.

ABSTRACT

Solar absorptance and thermal emittance of spacecraft materials are critical parameters in determining spacecraft temperature control. Because thickness, surface preparation, coatings formulation, manufacturing techniques, etc. affect these parameters, it is usually necessary to measure the absorptance and emittance of materials before they are used. Also, because most materials exhibit some amount of degradation due to outgassing, ultraviolet, and or particle damage, it is necessary to conduct laboratory testing on these materials before certifying them for use in space.

This document contains absorptance and emittance data for many common types of thermal-control coatings, together with some sample spectral data curves of absorptance. In cases for which ultraviolet and particle radiation data are available, the degraded absorptance and emittance values are also listed.

CONTENTS

SOLAR ABSORPTANCE AND THERMAL EMITTANCE DATA OF SOME COMMON SPACECRAFT THERMAL-CONTROL COATINGS

John H. Henninger
Goddard Space Flight Center
Greenbelt, Maryland

INTRODUCTION

The Radiation Simulation and Thermal Control Section of the Environmental Test and Integration Branch of the Goddard Space Flight Center (GSFC) routinely makes measurements on spacecraft materials to determine their solar absorptance and thermal emittance ($\bar{\alpha}_s$ and $\bar{\epsilon}_n$) values for use in spacecraft thermal design. Except for calorimetric emittance, all measurements are made at room temperature (300 K). It is normally assumed that samples are opaque (i.e., the thickness of the coatings is sufficient to prevent interference from the substrate). Opacity is important because surface preparation, coatings formulation, manufacturing techniques, thickness, and application procedures can greatly affect the absorptance and emittance.

The importance of the solar absorptance for spacecraft temperature arises from the fact that the absorbed solar radiation is typically the predominant external heat input to the spacecraft. The importance of the thermal emittance is that it controls the rate at which heat leaves the spacecraft. A clearer idea of the effect of these parameters on spacecraft temperature can be obtained by considering the very simple case of a body in thermal equilibrium with solar radiation (i.e., there are no other external heat sources and there is no source within the body). In addition, the body is isothermal. For these conditions, the thermal equilibrium of the body implies that the solar radiation absorbed equals the long-wave radiation emitted (reference 1). This is expressed as:

$$A_s s\alpha = A\sigma \epsilon T^4$$

or solving for T gives:

$$T = \left[\frac{A_s}{A} \cdot \frac{s}{\sigma} \cdot \frac{\alpha}{\epsilon}\right]^{1/4}$$

where

T = temperature
A_s = area perpendicular to solar radiation
A = total area emitting radiation
s = solar constant

α = absorptance

ϵ = emittance

σ = Boltzmann's constant

From these equations, it is evident that the selection of materials on the basis of their absorptance and emittance values is of primary importance in spacecraft temperature control.

DESCRIPTION OF MEASUREMENTS

Solar Absorptance ($\bar{\alpha}_s$) Measurement

To obtain solar absorptance of a material, reflectance as a function of wavelength is measured, from which the absorptance is then calculated. The technique used at GSFC employs a spectrophotometer with an integrating sphere attachment (reference 2) for collecting the reflected specular and diffuse components of the material to obtain total reflectance versus wavelength values. The reflectance measurements are made over the portion of the electromagnetic spectrum from 0.3 to 2.4 micrometers because this region contains about 95 percent of the Sun's energy (reference 3).

Figures 1 through 20 show reflectance curves for some common materials.

Mathematically expressed, the procedure for computing the solar absorptance of a given material from its total reflectance spectrum (specular and diffuse components) at a given angle of incidence, θ (reference 4), is:

$$\bar{\alpha}(\theta) = 1 - \bar{\rho}(\theta)$$

$$\bar{\rho}(\theta) = \frac{\int_{\lambda = 0.3\ \mu m}^{\lambda = 2.4\ \mu m} R\lambda(\theta)\, H\lambda\, d\lambda}{\int_{\lambda = 0.3\ \mu m}^{\lambda = 2.4\ \mu m} H\lambda\, d\lambda}$$

where

$\bar{\alpha}(\theta)$ = solar absorptance at angle of incidence θ

$R\lambda(\theta)$ = total reflectance at wavelength λ at θ

$H\lambda$ = solar extraterrestial spectrum

$\bar{\rho}(\theta)$ = solar reflectance at θ

In practice, the integrals are approximated by discrete summations (numerical integration).

At GSFC, manual data reduction for absorptance has been replaced by using encoders attached to the pen and wavelength drives of the DK-2 spectrophotometer. Data from the encoders are transferred to a microcomputer through an appropriate interface. A 'basic' computer program is used to process the encoded data and automatically calculate the absorptance of the material.

Normal Emittance ($\bar{\epsilon}_n$)

In the past at GSFC, room-temperature emittance measurements (300 K) were made using an infrared spectrophotometer with an attached heated cavity (Holhraum), (reference 5). This infrared source was used both as a reference and for illuminating the sample. Spectral reflectance measurements were made over the wavelength region from 5 to 35 micrometers. This region contains approximately 90 percent of the energy of a 300 K blackbody radiator (reference 1). These data were used to calculate the emittance. This type of instrumentation was difficult to maintain and has been replaced at GSFC with the much simpler portable emissometer manufactured by the Gier-Dunkle Instrument Company, a subsidiary of Dynatech, Incorporated.* The DB-100 portable emissometer gives an integrated value of normal emittance with a high degree of accuracy for most nonselective or gray materials. For selective materials (reference 6), the errors can be significant, but these errors can be minimized by the experienced operator if correction factors are known or can be determined. Normal emittance measurements ($\bar{\epsilon}_n$) are converted to hemispherical emittance ($\bar{\epsilon}_h$) by using conversion factors determined by Jakob (reference 7).

The following formulas are used for computing total normal emittance, $\bar{\epsilon}_n$ (reference 4):

$$\bar{\epsilon}_n(T) = \bar{\alpha}_n(T)$$

$$\bar{\alpha}_n(T) = 1 - \bar{\rho}_n(T)$$

$$\bar{\rho}_n(T) = \frac{\int_{\lambda = 5\ \mu m}^{\lambda = 35\ \mu m} \rho_n(\lambda)\, J\lambda(T) d\lambda}{\int_{\lambda = 5\ \mu m}^{\lambda = 35\ \mu m} J\lambda(T)\, d\lambda}$$

$J\lambda(T)$ = Planckian blackbody function

$\bar{\epsilon}_n(T)$ = Total normal emittance at T

$\bar{\alpha}_n(T)$ = Total normal absorptance at T

$\bar{\rho}_n(T)$ = Total normal reflectance at T

In actual computations, discrete summations are used in place of the foregoing integrals.

Calorimetric Emittance

Another method of making emittance measurements, developed and in use at GSFC, employs a calorimetric technique to determine emittance. This method is known as a transient thermal

*Gier-Dunkle, Incorporated, Santa Monica, California.

technique for obtaining emittance. A complete description of the calorimetric facility and measurement technique is given in reference 4.

INSTRUMENTATION

Many different type spectrophotometers are available for use in making absorptance and emittance measurements. The systems at GSFC have been in use since 1965. Some modifications have been made in recent years, mainly in the areas of computerized data reduction and integrating sphere-coating improvements. The sodium chloride (NaCl) and barium sulfate ($BaSO_4$) coatings used today have proved to be much more durable than the old 'smoked' magnesium oxide (MgO) coatings.

Solar Absorptance ($\overline{\alpha}_s$)

A Beckman DK-2A spectrophotometer modified with a Gier-Dunkle absolute integrating sphere (Figure 21) is used for making absolute reflectance, absorptance, and transmittance measurements. This instrument covers the wavelength region from 300 to 2400 nanometers (nm). The instrument is coupled to a microcomputer for data reduction. The manufacturer's data lists an accuracy of α_s ±0.015 units over the total measurement range.

Normal Emittance ($\overline{\epsilon}_n$)

The Gier-Dunkle portable emissometer, model DB-100 (Figure 22) is used to make normal emittance measurements at room temperature. This instrument gives a single integrated value of emittance. It uses dual rotating cavities that reference sample radiation against an essentially room-temperature blackbody. The instrument has a potassium bromide (KBr) thermocouple detector, which is sensitive over the 5- to 25-micrometer wavelength range. The manufacturer's data lists an accuracy of $\overline{\epsilon}_n$ ±0.02 units over the total measurement range for nonselective materials and $\overline{\epsilon}_n$ ±0.04 for most selective materials.

Hemispherical Emittance ($\overline{\epsilon}_h$)

The hemispherical emittance system is composed of a high-vacuum chamber with a liquid nitrogen (LN_2) cooled shroud (Figure 23). The inside of the shroud is painted with a highly absorbing black paint. Vacuum pressure is maintained at 10^{-6} torr, whereas the shroud is kept at liquid nitrogen temperature. Samples are suspended within the shroud and are heated through a 5-inch diameter quartz port using an X25 solar simulator.* Calorimetric emittance measurements can be made over a temperature range of +70° to -70°C using this system. A larger temperature range can be obtained for some types of materials. Data reduction for emittance is accomplished with the aid of a microcomputer using the temperature versus time data.

ULTRAVIOLET DEGRADATION TESTING

Because many materials used for thermal-control purposes exhibit degradation when exposed to ultraviolet (UV) or particle radiation, efforts to simulate this degradation have been carried out on

*Manufactured by Spectrolab, Incorporated, Los Angeles, California.

many types of coatings. The object of the degradation testing has been to determine if the materials to be used will survive their planned missions without exceeding a predetermined degradation value.

A complete list and description of degradation testing facilities at GSFC has been published (reference 8). This list includes a solar-wind facility (Figure 24) (UV and protons), vudarms system (UV and reflectance), and multisedes system (Figure 25) (multisample UV and reflectance).

The X-25 solar simulator is the source used for ultraviolet degradation because it gives a very good match with the solar spectrum. Since certain materials are subject to partial recovery from degradation effects (UV and particles) when re-exposed to the atmosphere, it is often necessary to make measurements *in situ* to determine accurate changes in absorptance values.

CONCLUSIONS

Because a continual need exists for measurements in thermal-control analysis, absorptance and emittance measurements will continue to be made on old and new materials. With future Shuttle flights, $\bar{\alpha}_s$ and $\bar{\epsilon}_n$ values will be necessary in support of instrumentation and as a check for contamination of various flight surfaces. Absorptance and emittance values are not the sole criteria for selecting coatings because selection usually represents a compromise of many factors. Coatings stability in space, mission life, orbit factors, instrument functions, and coatings outgassing properties are some of the more important criteria in selecting a coating for flight use.

This document lists only the more commonly used and requested data. The values are average ones that generally reflect a tolerance on absorptance and emittance of ±0.02 units over the total measurement range (e.g., ($\bar{\alpha}_s$ or $\bar{\epsilon}_n$ - 0.XX ±0.02)). Because, as previously mentioned, many factors can influence absorptance and emittance values, it is suggested that confirmation measurements should be made on specific sample materials before final commitment to spaceflight use.

Goddard Space Flight Center
National Aeronautics and Space Administration
Greenbelt, Maryland December 1983

BLACK COATINGS

	$\bar{\alpha}_s$	$\bar{\epsilon}_n$
Anodize Black	0.88	0.88
Carbon Black Paint NS-7	0.96	0.88
Catalac Black Paint	0.96	0.88
Chemglaze Black Paint Z306	0.96	0.91
Delrin Black Plastic	0.96	0.87
Ebanol C Black	0.97	0.73
Ebanol C Black–384 ESH* UV	0.97	0.75
GSFC Black Silicate MS-94	0.96	0.89
GSFC Black Paint 313-1	0.96	0.86
Hughson Black Paint H322	0.96	0.86
Hughson Black Paint L-300	0.95	0.84
Martin Black Paint N-150-1	0.94	0.94
Martin Black Velvet Paint	0.91	0.94
3M Black Velvet Paint	0.97	0.91
Paladin Black Lacquer	0.95	0.75
Parsons Black Paint	0.98	0.91
Polyethylene Black Plastic	0.93	0.92
Pyramil Black on Beryllium Copper	0.92	0.72
Tedlar Black Plastic	0.94	0.90
Velestat Black Plastic	0.96	0.85

*ESH = equivalent Sun hours of ultraviolet radiation.

WHITE COATINGS

	$\bar{\alpha}_s$	$\bar{\epsilon}_n$
Barium Sulphate with Polyvinyl Alcohol	0.06	0.88
Biphenyl–White Solid	0.23	0.86
Catalac White Paint	0.24	0.90
Dupont Lucite Acrylic Lacquer	0.35	0.90
Dow Corning White Paint DC-007	0.19	0.88
GSFC White Paint NS43-C	0.20	0.92
GSFC White Paint NS44-B	0.34	0.91
GSFC White Paint MS-74	0.17	0.92
GSFC White Paint NS-37	0.36	0.91
Hughson White Paint A-276	0.26	0.88
Hughson White Paint A-276 + 1036 ESH UV	0.44	0.88
Hughson White Paint V-200	0.26	0.89
Hughson White Paint Z-202	0.25	0.87
Hughson White Paint Z-202 + 1000 ESH UV	0.40	0.87
Hughson White Paint Z-255	0.25	0.89
Mautz White House Paint	0.30	0.90
3M-401 White Paint	0.25	0.91
Magnesium Oxide White Paint	0.09	0.90
Magnesium Oxide Aluminium Oxide Paint	0.09	0.92
Opal Glass	0.28	0.87
OSO-H White Paint 63W	0.27	0.83
P764-1A White Paint	0.23	0.92
Potassium Fluorotitanate White Paint	0.15	0.88
Sherwin Williams White Paint (A8W11)	0.28	0.87
Sherwin Williams White Paint (F8W2030)	0.39	0.82
Sherwin Williams F8W2030 with Polasol V6V241	0.36	0.87
Sperex White Paint	0.34	0.85
Tedlar White Plastic	0.39	0.87
Titanium Oxide White Paint with Methyl Silicone	0.20	0.90
Titanium Oxide White Paint with Potassium Silicate	0.17	0.92
Zerlauts S-13G White Paint	0.20	0.90
Zerlauts Z-93 White Paint	0.17	0.92
Zinc Orthotitanate with Potassium Silicate	0.13	0.92
Zinc Oxide with Sodium Silicate	0.15	0.92
Zirconium Oxide with 650 Glass Resin	0.23	0.88

CONDUCTIVE PAINTS

	$\bar{\alpha}_s$	$\bar{\epsilon}_n$
Brilliant Aluminum Paint	0.30	0.31
Epoxy Aluminum Paint	0.77	0.81
Finch Aluminum Paint 643-1-1	0.22	0.23
Leafing Aluminum in Epon 828	0.37	0.36
Leafing Aluminum (80-U)	0.29	0.32
NRL Leafing Aluminum Paint	0.24	0.24
NRL Leafing Aluminum Paint	0.28	0.29
Silicone Aluminum Paint	0.29	0.30
Dupont Silver Paint 4817	0.43	0.49
Chromeric Silver Paint 586	0.30	0.30
GSFC Yellow NS-43-G	0.38	0.90
GSFC Green NS-53-B	0.52	0.87
GSFC Green NS-43-E	0.57	0.89
GSFC White NS-43-C	0.20	0.92
GSFC Green NS-55-F	0.57	0.91
GSFC Green NS-79	0.57	0.91

ANODIZED ALUMINUM SAMPLES*

	$\bar{\alpha}_s$	$\bar{\epsilon}_n$
Black	0.65	0.82
Black	0.86	0.86
Blue	0.67	0.87
Blue	0.53	0.82
Brown	0.73	0.86
Chromic	0.44	0.56
Clear	0.27	0.76
Clear	0.35	0.84
Green	0.66	0.88
Gold	0.48	0.82
Plain	0.26	0.04
Red	0.57	0.88
Sulphuric	0.42	0.87
Yellow	0.47	0.87
Blue Anodized Titanium Foil	0.70	0.13

*Coating thickness is critical.

METALS AND CONVERSION* COATINGS

	$\bar{\alpha}_s$	$\bar{\epsilon}_n$
Alzac A-2	0.16	0.73
Alzac A-5	0.18	- -
Black Chrome	0.96	0.62
Black Copper	0.98	0.63
Black Irridite	0.62	0.17
Black Nickel	0.91	0.66
Buffed Aluminum	0.16	0.03
Buffed Copper	0.30	0.03
Constantan–Metal Strip	0.37	0.09
Copper Foil Tape		
Plain	0.32	0.02
Sanded	0.26	0.04
Tarnished	0.55	0.04
Dow 7 on Polished Magnesium	- -	0.49
Dow 7 on Sanded Magnesium	- -	0.65
Dow 9 on Magnesium	- -	0.87
Dow 23 on Magnesium	0.62	0.67
Ebanol C Black	0.97	0.77
Electroplated Gold	0.23	0.03
Electroless Nickel	0.39	0.07
Irridite Aluminum	- -	0.11
Inconel X Foil (1 mil)	0.52	0.10
Kannigen–Nickel Alloy	0.45	0.08
Plain Beryllium Copper	0.31	0.03
Platinum Foil	0.33	0.04
Stainless Steel		
Polished	0.42	0.11
Machined	0.47	0.14
Sandblasted	0.58	0.38
Machine Rolled	0.39	0.11
Boom-Polished	0.44	0.10
1-mil 304 Foil	0.40	0.05
Tantalum Foil	0.40	0.05
Tungsten Polished	0.44	0.03

*Thickness of coating can change values significantly.

VAPOR-DEPOSITED COATINGS*

	$\bar{\alpha}_s$	$\bar{\epsilon}_n$
Aluminum	0.08	0.02
Aluminum on Fiberglass	0.15	0.07
Aluminum on Stainless Steel	0.08	0.02
Chromium	0.56	0.17
Chromium on 5-mil Kapton	0.57	0.24
Germanium	0.52	0.09
Gold	0.19	0.02
Iron Oxide	0.85	0.56
Molybdenum	0.56	0.21
Nickel	0.38	0.04
Rhodium	0.18	0.03
Silver	0.04	0.02
Titanium	0.52	0.12
Tungsten	0.60	0.27

*On glass substrates except as noted.

SOLAR CELLS

Spacecraft	$\bar{\alpha}_s$	$\bar{\epsilon}_n$
AE	0.78	0.82
AMSAT	0.82	0.85
ATN Black	0.77	0.80
ATN Blue	0.86	0.85
ATS-F	0.85	0.85
COMSAT	0.82	0.85
DE	0.77	0.81
ETS/GOES	0.82	0.80
GOES	0.91	0.81
GPS–Conductive Coating	0.81	0.80
HELIOS	0.80	0.82
IME–Conductive Coating	0.75	0.79
IMP-H	0.78	0.82
IMP-I	0.78	0.81
ISEE–Conductive Coating	0.91	0.79
IUE	0.86	0.84
OAO	0.85	0.81
PAC	0.77	0.81
SMS-B	0.81	0.80
Spanish INTASAT	0.86	0.86
SSS	0.79	0.82

COMPOSITE COATINGS

	$\bar{\alpha}_s$	$\bar{\epsilon}_n$
Aluminum Oxide (Al_2O_3)–(12 λ/4) on Buffed Aluminum		
Initial	0.13	0.23
2560 ESH UV + P^+	0.13	0.23
Aluminum Oxide (Al_2O_3)–(12 λ/4) on Fused Silica	0.12	0.24
Silver Beryllium Copper (AgBeCu)	0.19	0.03
Kapton Overcoating	0.31	0.57
Parylene C Overcoating	0.22	0.34
Teflon Overcoating	0.12	0.38
GSFC Dark Mirror Coating–SiO-Cr-Al	0.86	0.04
GSFC Composite SiOx-Al_2O_3-Ag	0.07	0.68
Helios Second Surface Mirror/Silver Backing:		
Initial	0.07	0.79
24 Hours at 5 Suns	0.07	0.80
48 Hours at 11 Suns + P^+	0.08	0.79
Inconel with Teflon Overcoating–1 mil	0.55	0.46
Vespel Polyimide SP1	0.89	0.90

FILMS AND TAPES

	$\bar{\alpha}_s$	$\bar{\epsilon}_n$
Aclar Film (Aluminum Backing)		
1 mil	0.12	0.45
2 mil	0.11	0.62
5 mil	0.11	0.73
Kapton Film (Aluminum Backing)		
0.08 mil	0.23	0.24
0.15 mil	0.25	0.34
0.25 mil	0.31	0.45
0.50 mil	0.34	0.55
1.0 mil	0.38	0.67
1.5 mil	0.40	0.71
2.0 mil	0.41	0.75
3.0 mil	0.45	0.82
5.0 mil	0.46	0.86
Kapton Film (Chromium-Silicon Oxide-Aluminum Backing (Green))		
1.0 mil	0.79	0.78
Kapton Film (Aluminum-Aluminum Oxide Overcoating)–1 mil		
Initial	0.12	0.20
1800 ESH UV	0.12	0.20
Kapton Film (Aluminum-Silicon Oxide Overcoating)–1 mil		
Initial	0.11	0.33
2400 ESH UV	0.22	0.33
Kapton Film (Silver-Aluminum Oxide Overcoating)–1 mil		
Initial	0.08	0.19
2400 ESH UV	0.08	0.21
Kapton Film (Aluminum-Silicon Oxide Overcoating)–0.5 mil		
Initial	0.12	0.18
4000 ESH UV	0.28	0.24
Kimfoil-Polycarbonate Film (Aluminum Backing)		
0.08 mil	0.19	0.23
0.20 mil	0.20	0.30
0.24 mil	0.17	0.28

FILMS AND TAPES (Continued)

	$\bar{\alpha}_s$	$\bar{\epsilon}_n$
Mylar Film		
Aluminum Backing		
0.15 mil	0.14	0.28
0.25 mil	0.15	0.34
3.0 mil	0.17	0.76
5.0 mil	0.19	0.77
Skylab Sail		
Initial	0.15	0.35
1900 ESH UV	0.19	0.36
Skylab Parasol Fabric (Orange)		
Initial	0.51	0.86
2400 ESH UV	0.65	0.86
Tedlar (Gold Backing)		
0.5 mil	0.30	0.49
1.0 mil	0.26	0.58
Teflon		
Aluminum Backing		
2 mil	0.08	0.66
5 mil	0.13	0.81
10 mil	0.13	0.87
Gold Backing		
0.5 mil	0.24	0.43
1.0 mil	0.22	0.52
5 mil	0.22	0.81
10 mil	0.23	0.82
Silver Backing		
2 mil	0.08	0.68
5 mil	0.08	0.81
10 mil	0.09	0.88
Tefzel (Gold Backing)		
0.05 mil	0.29	0.47
1.0 mil	0.26	0.61
Tapes		
235–3M Black	0.95	0.90
425–3M Aluminum Foil	0.20	0.03
850–3M Mylar-Aluminum Backing	0.15	0.59
7361–Mystic Aluminized Kapton	0.09	0.03
7452–Mystic Aluminum Foil	0.14	0.03
7800–Mystic Aluminum Foil	0.21	0.03
Y9360–3M Aluminized Mylar	0.19	0.03

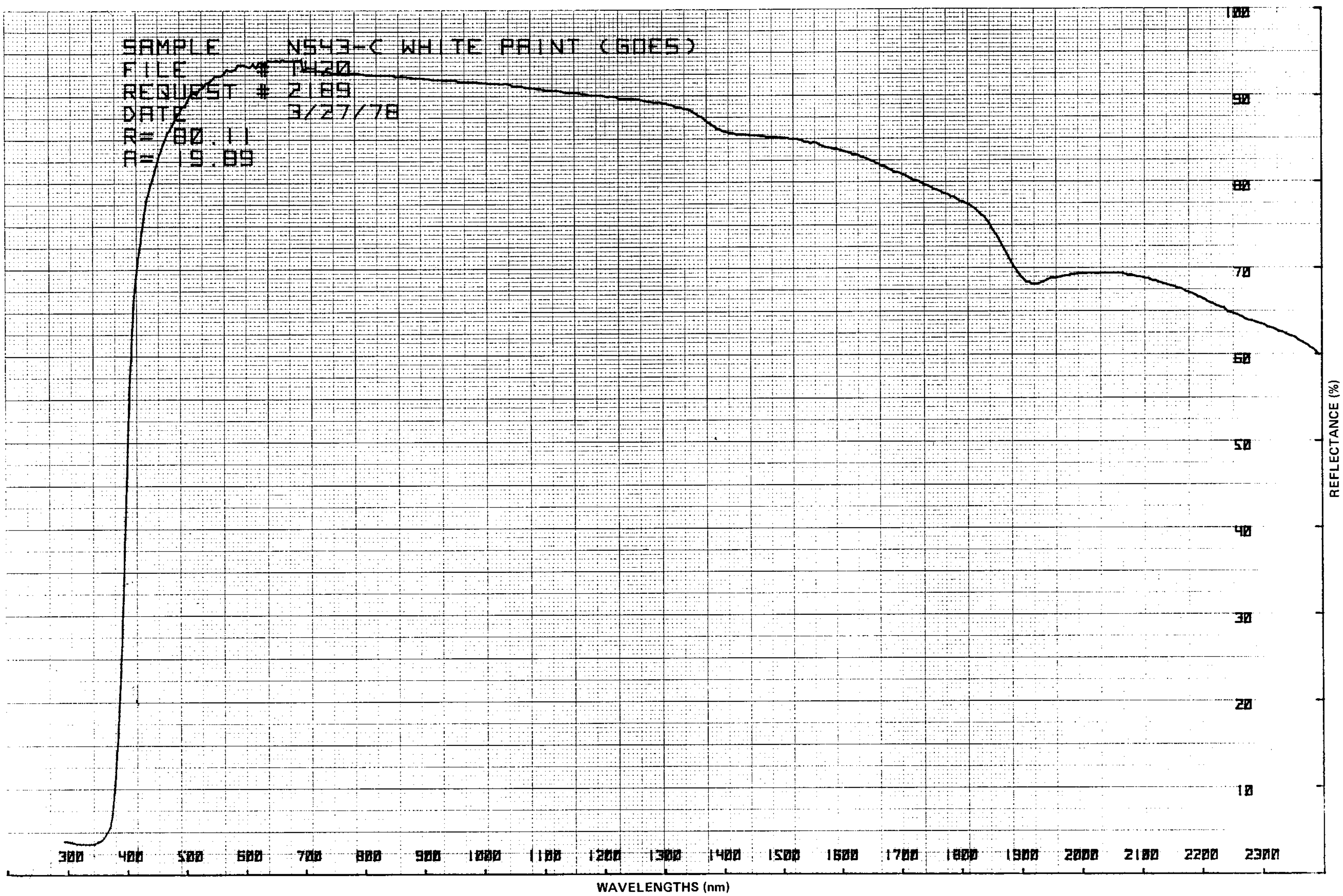

Figure 1. NS43-C White Paint (GOES).

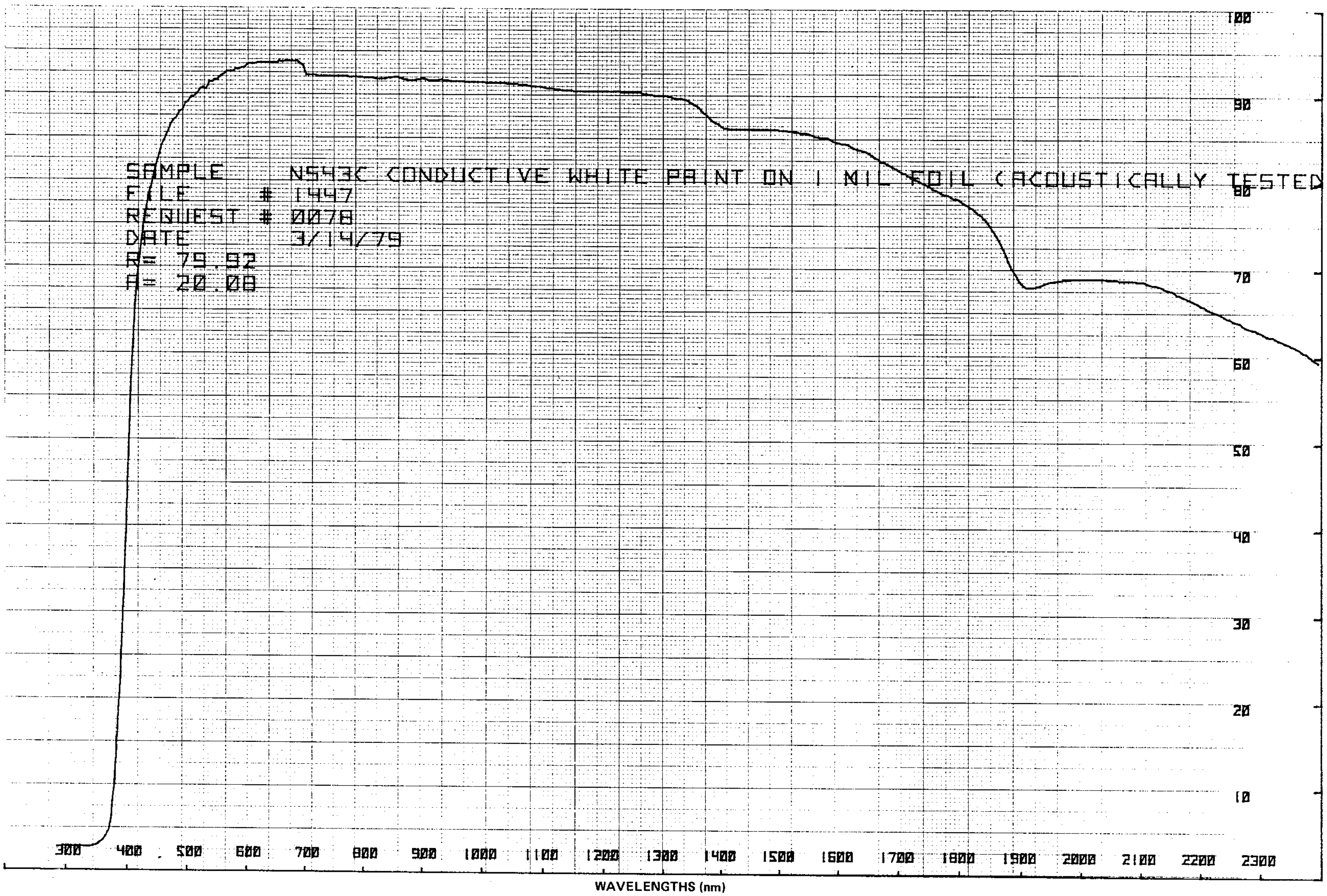

Figure 2. NS43-C Conductive White Paint on 1-Mil Foil (Acoustically Tested).

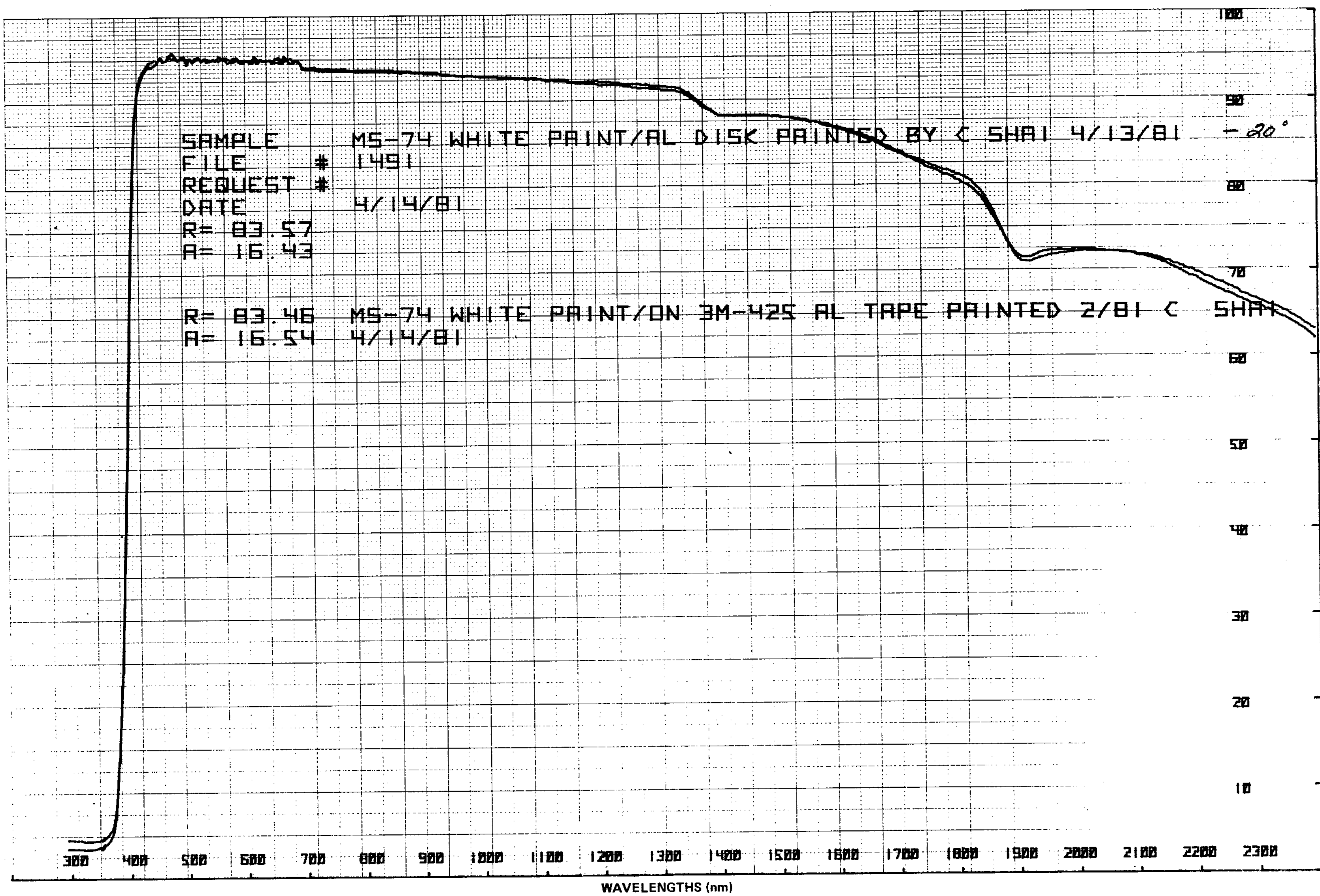

Figure 3. MS-74 White Paint on an Aluminum Disk and on 3M-425 Aluminum Tape.

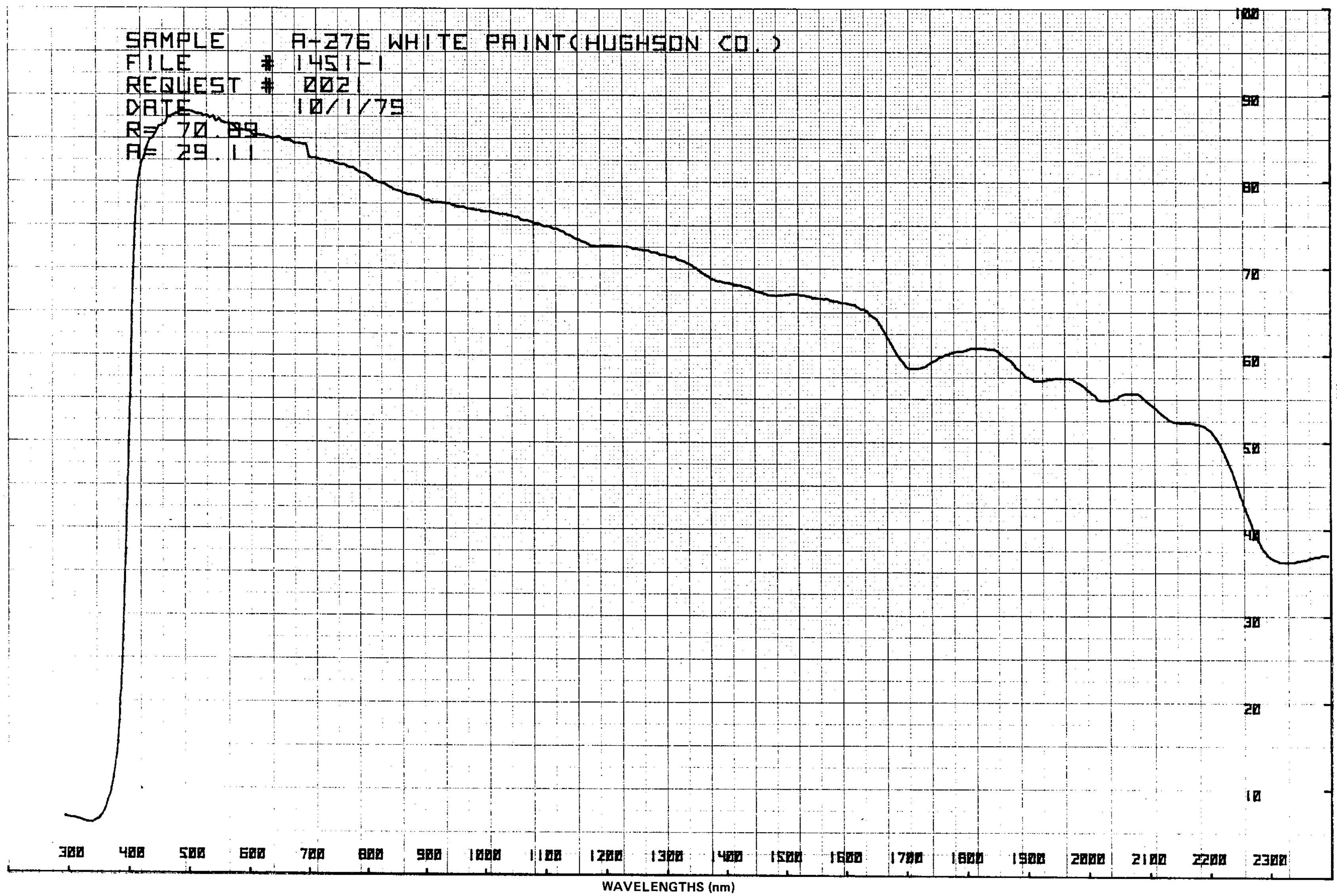

Figure 4. Hughson A-276 White Paint.

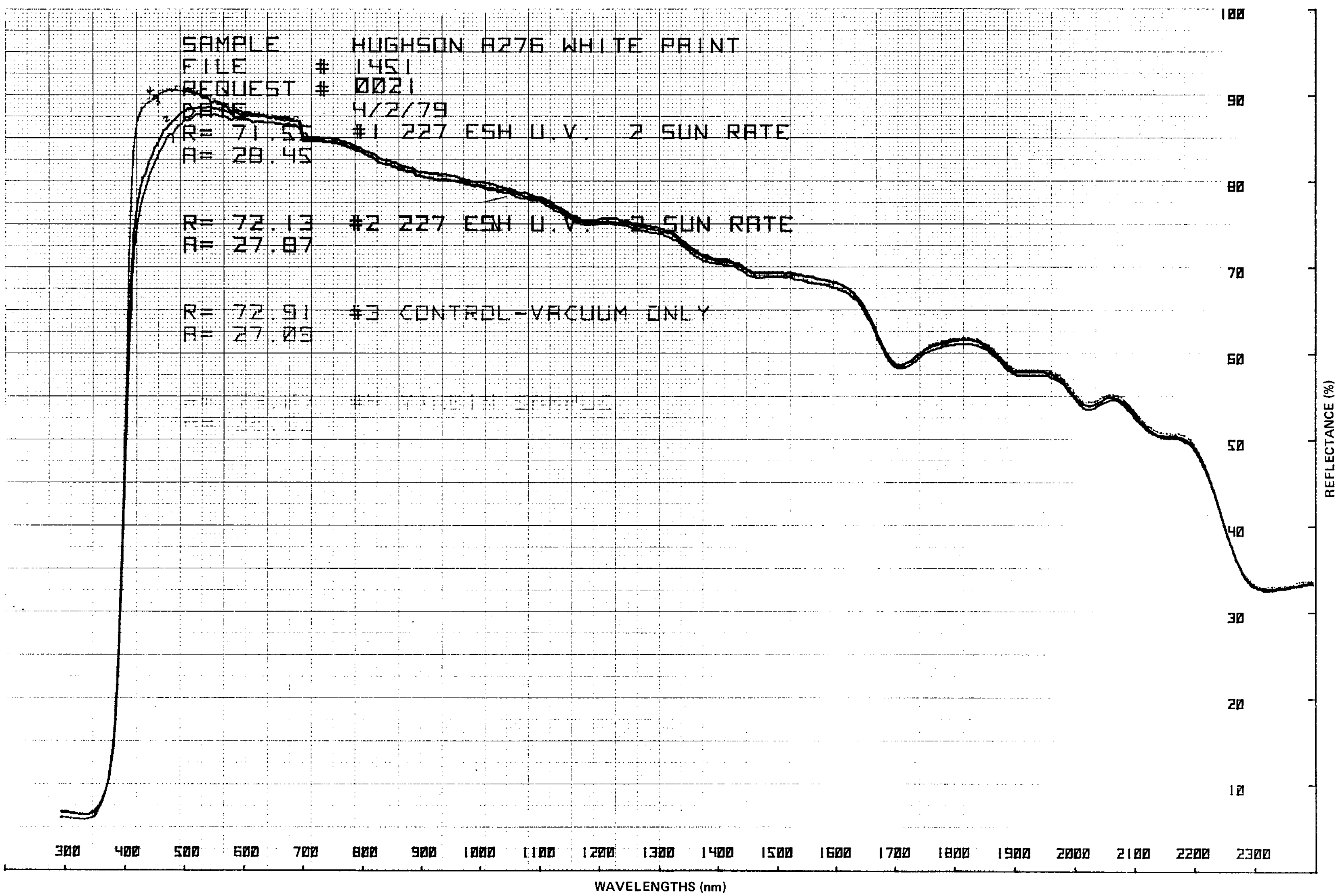

Figure 5. Hughson A-276 White Paint.

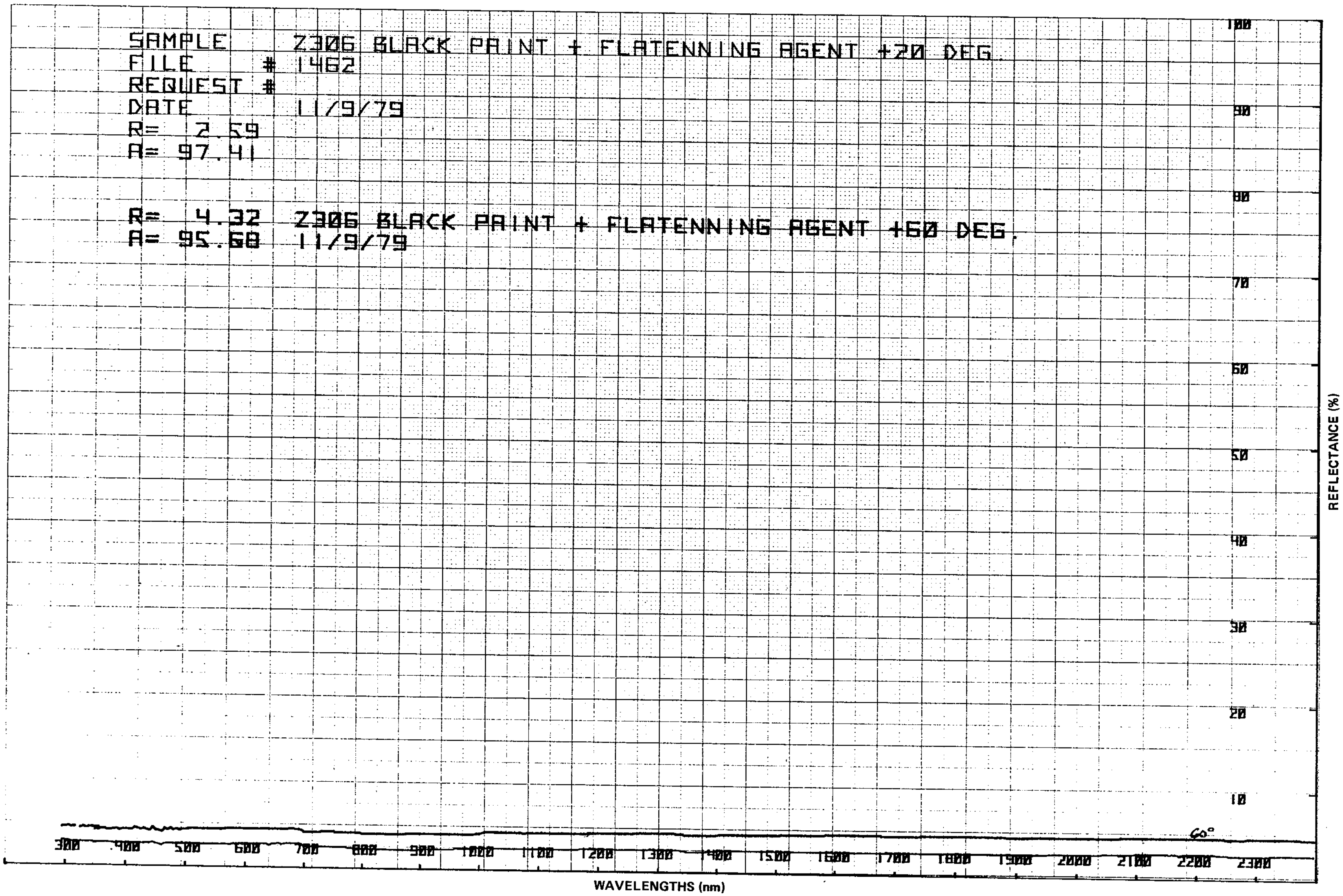

Figure 6. Z306 Black Paint Plus Flattening Agent at +20 and +60 Degrees.

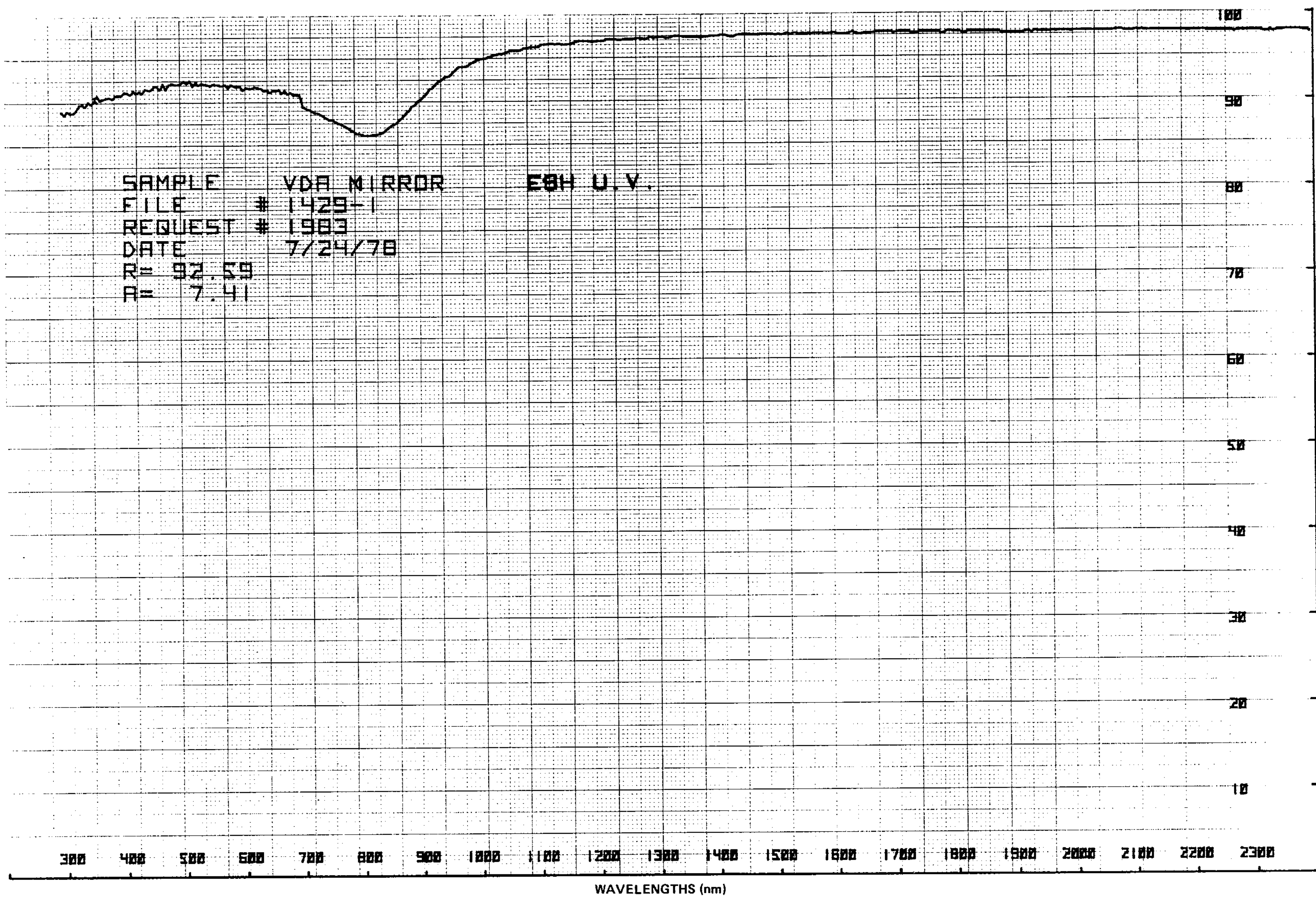

Figure 7. VDA Mirror (ESH Ultraviolet).

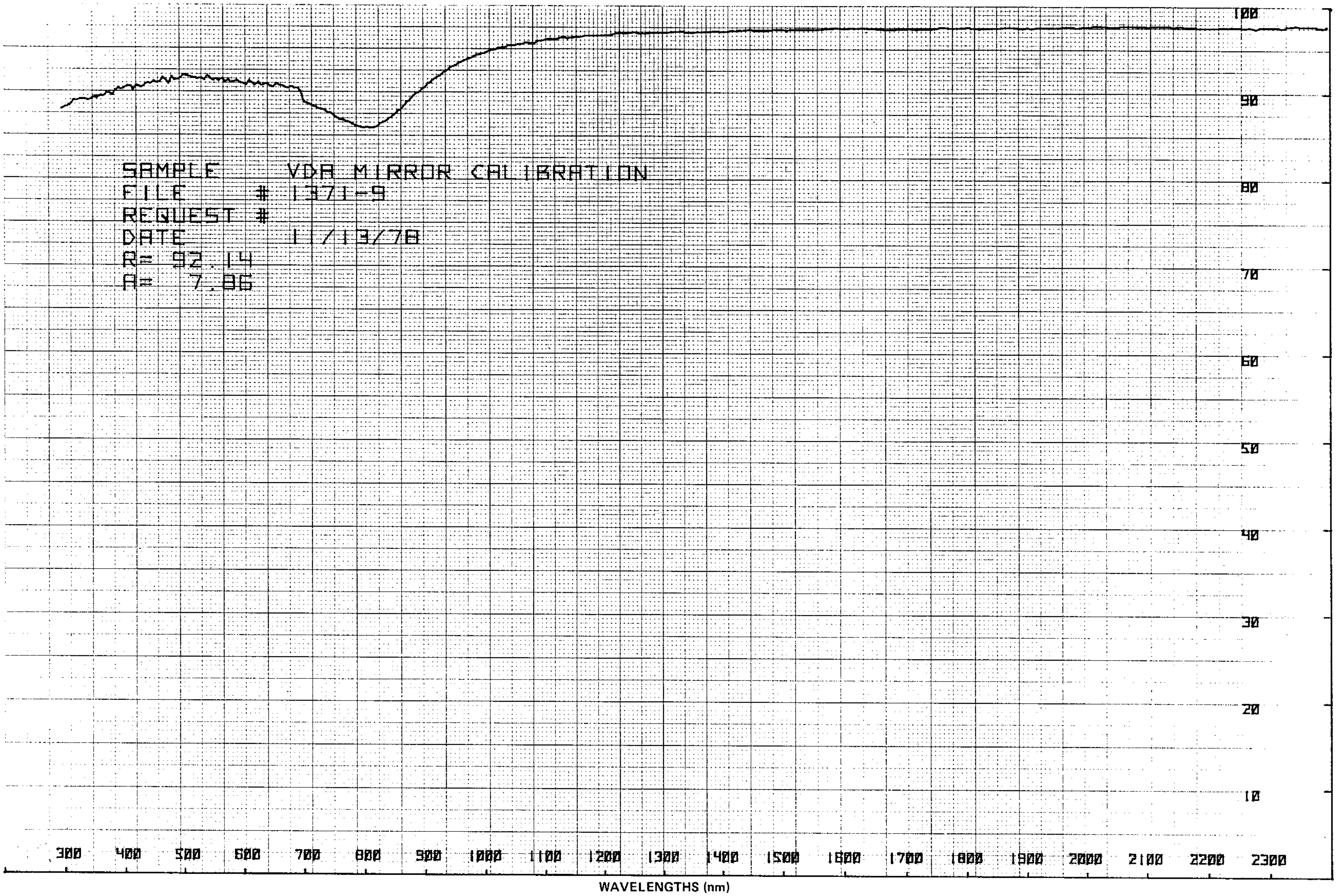

Figure 8. VDA Mirror Calibration.

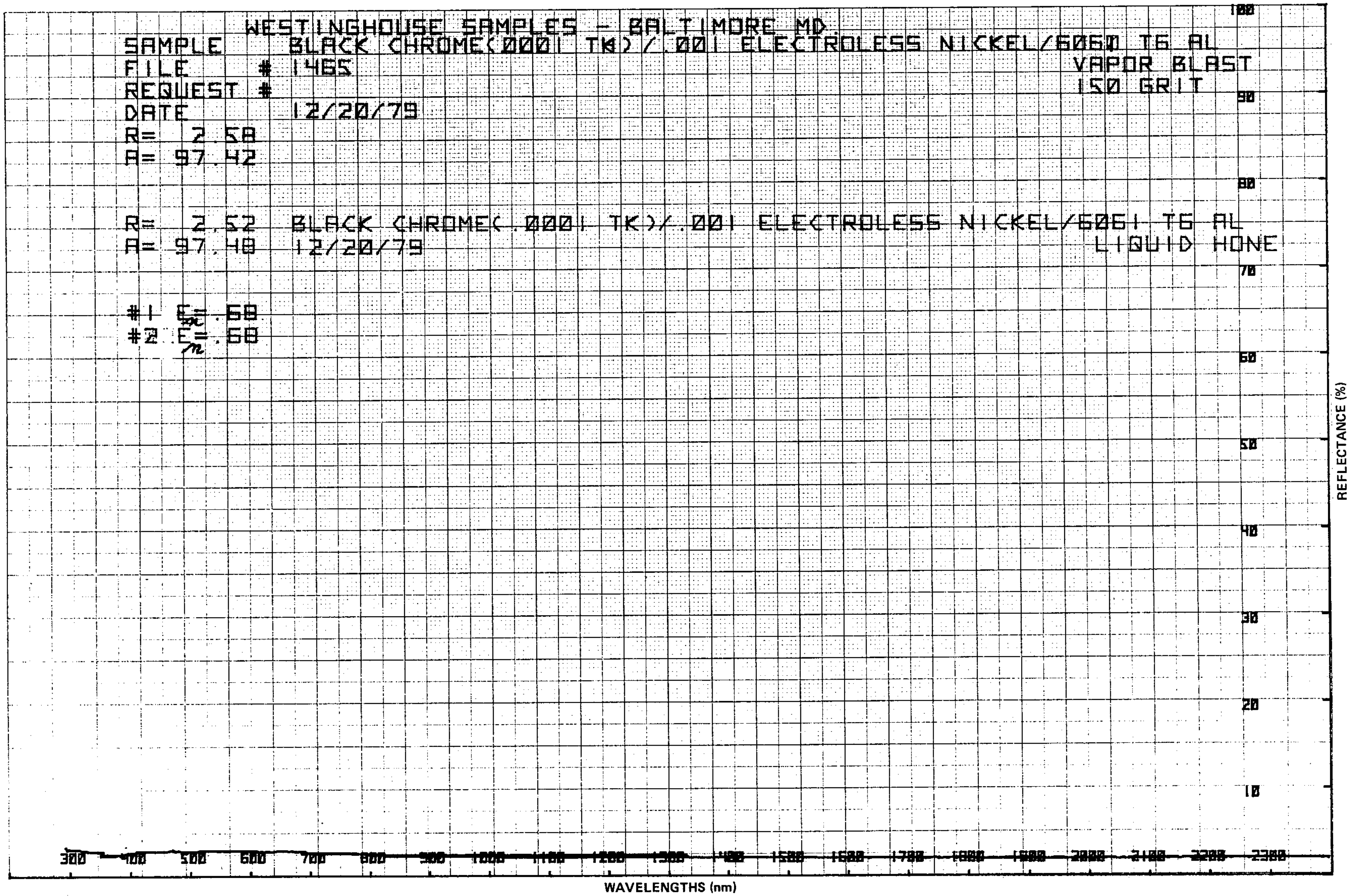

Figure 9. Westinghouse Black Chrome (0.001 TK) on 0.001 Electroless Nickel.

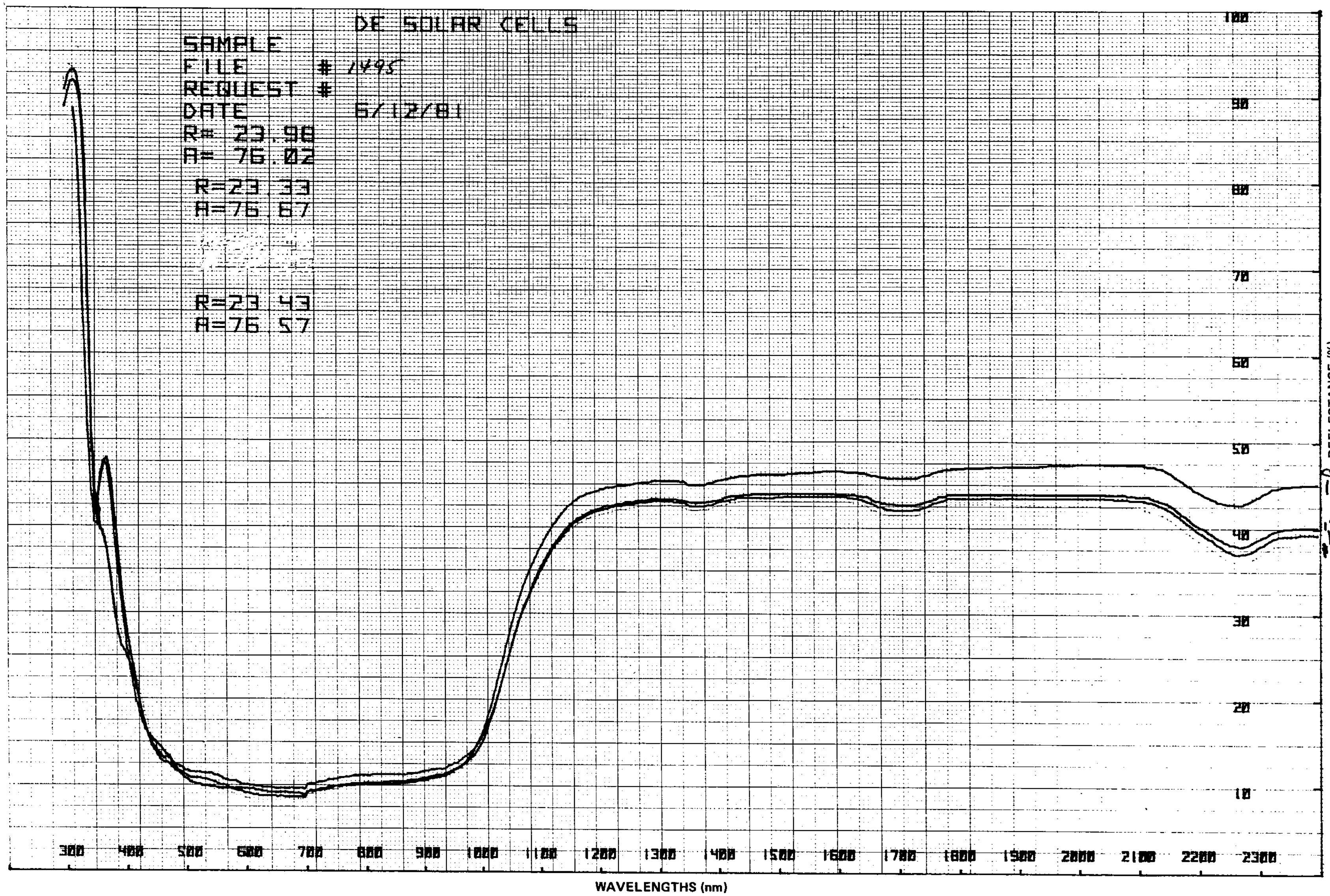

Figure 10. DE Solar Cells.

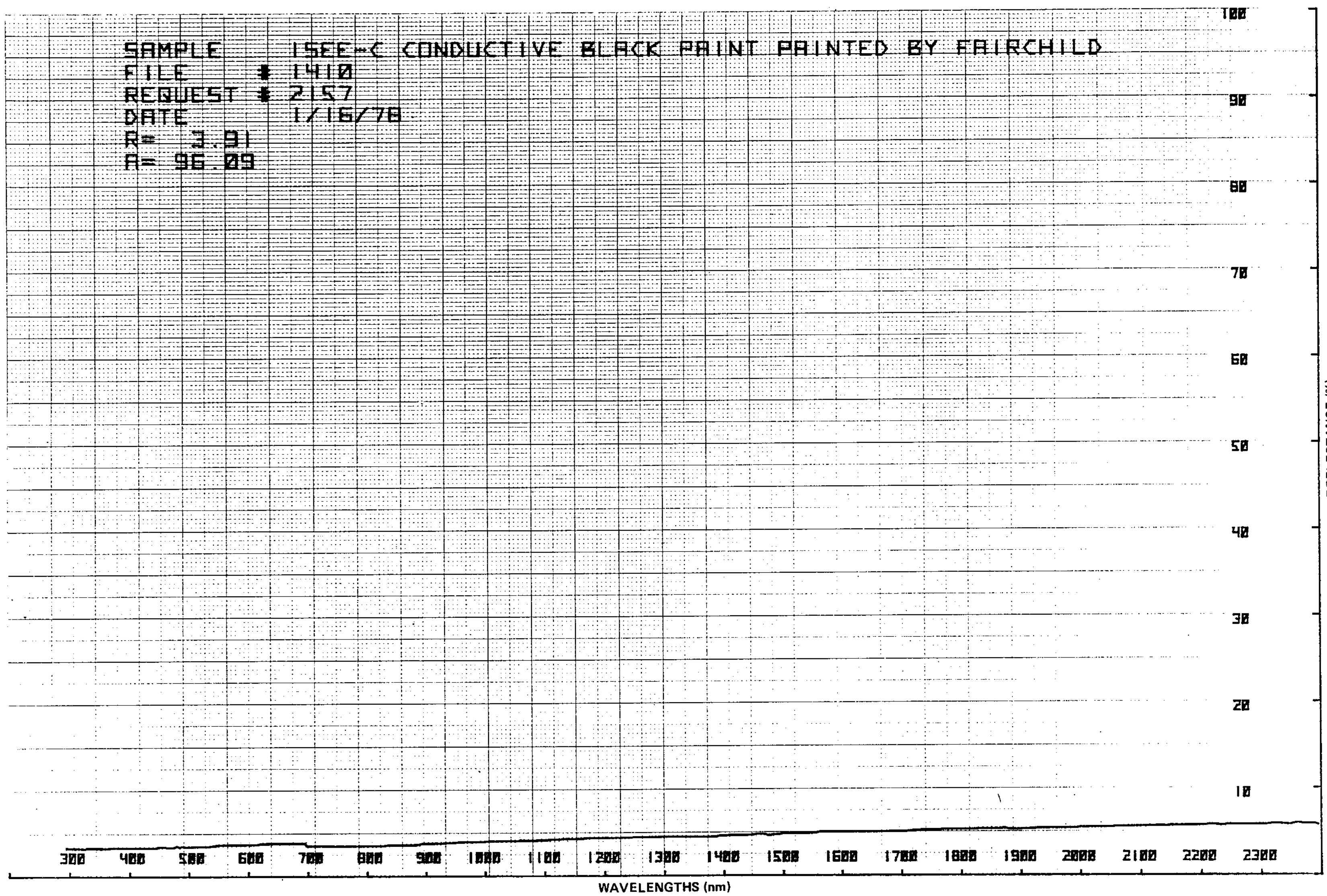

Figure 11. ISEE-C Conductive Black Paint.

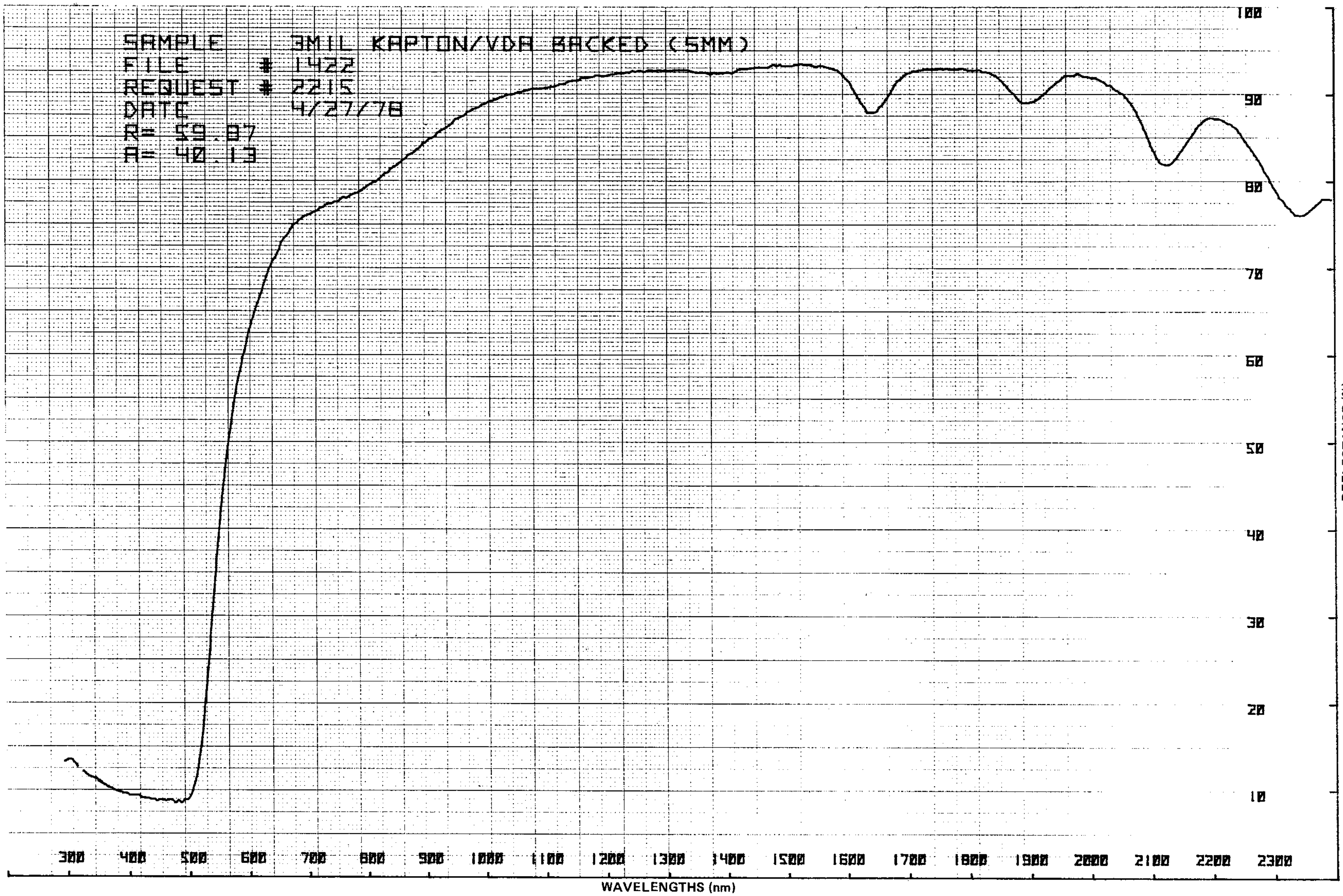

Figure 12. 3-Mil Kapton/VDA Backed (5 mm).

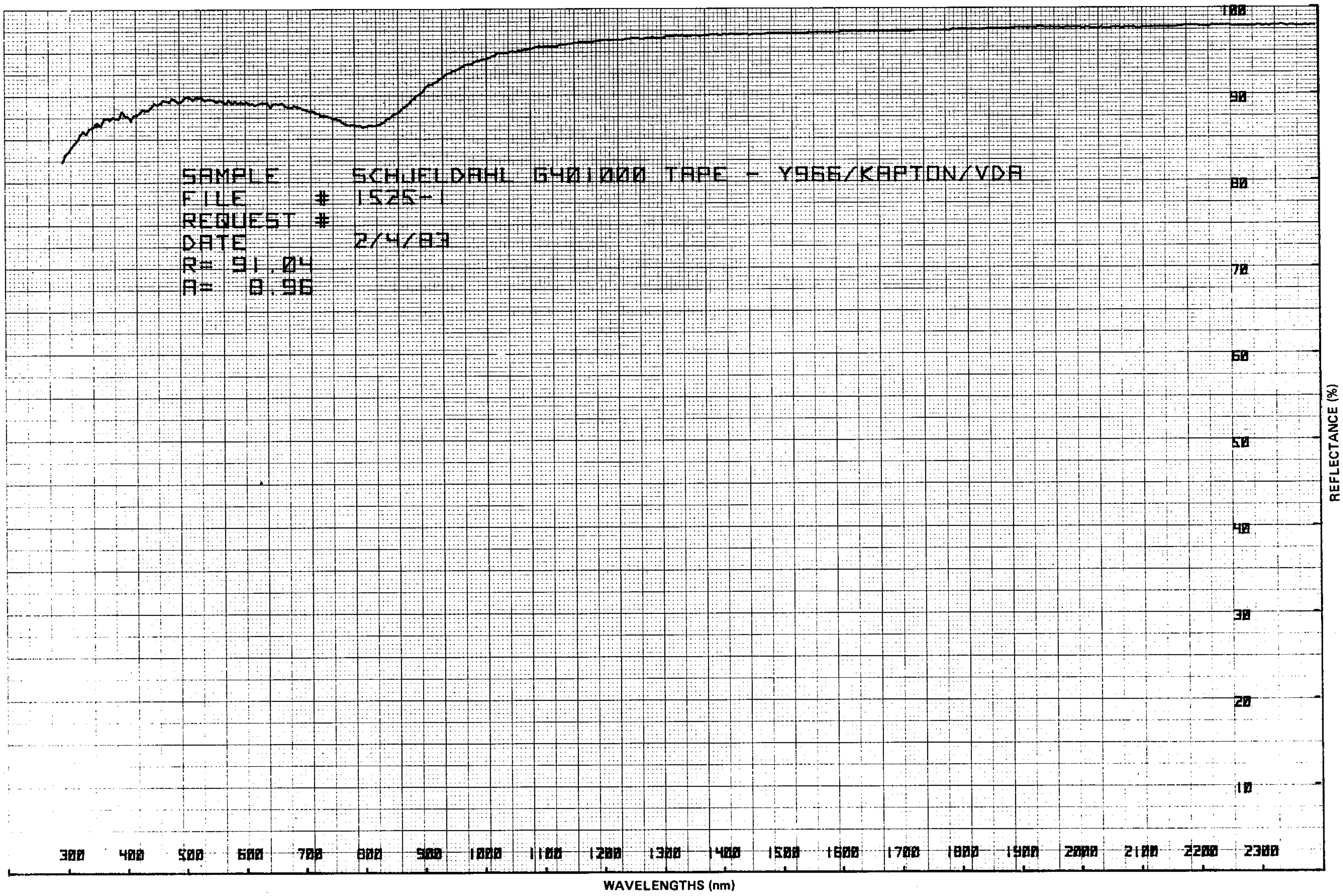

Figure 13. Schjeldahl G401000 Tape—Y966/Kapton/VDA.

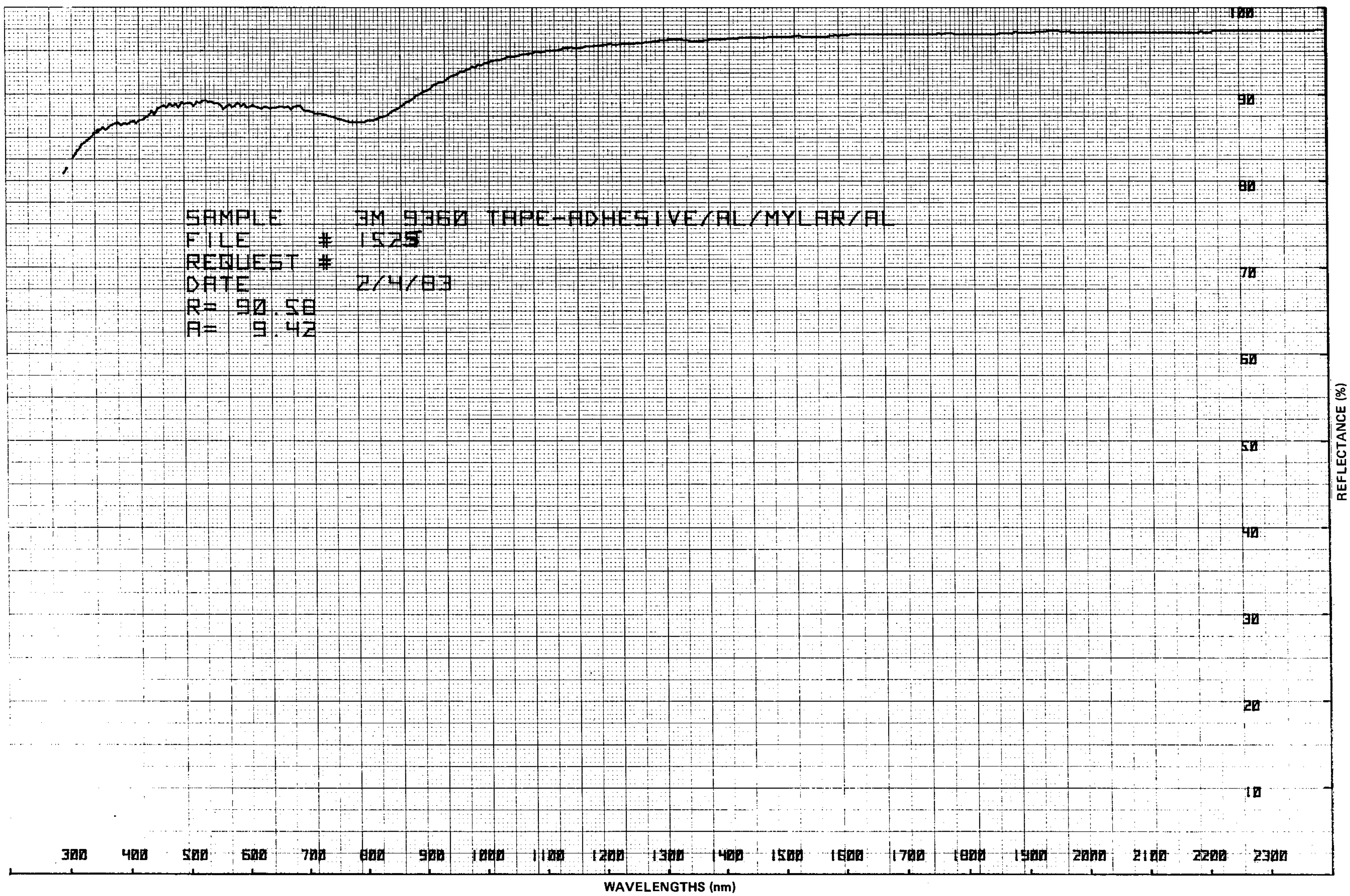

Figure 14. 3M 9360 Tape-Adhesive/Aluminum/Mylar/Aluminum.

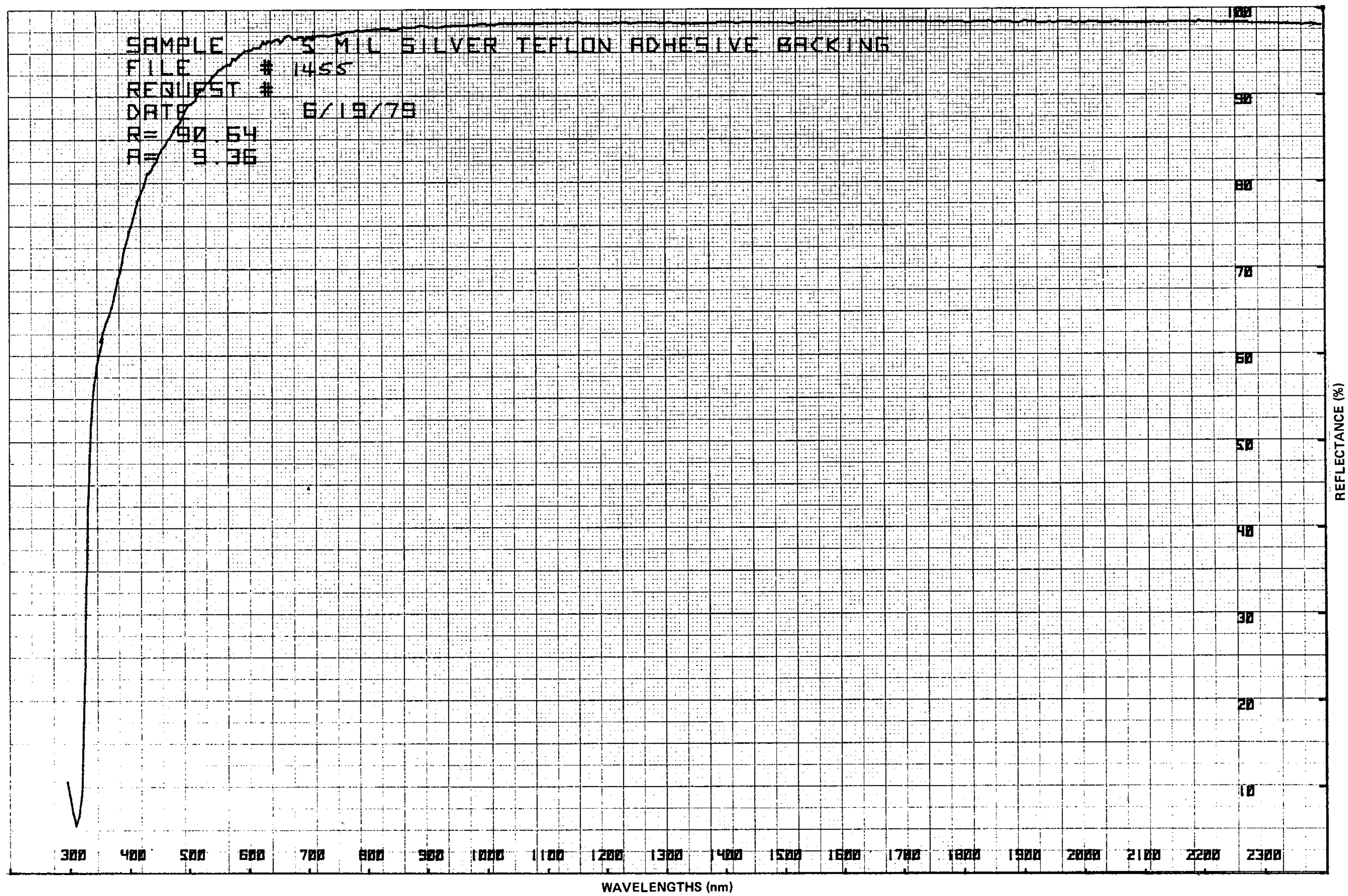

Figure 15. 5-Mil Silver Teflon Adhesive Backing.

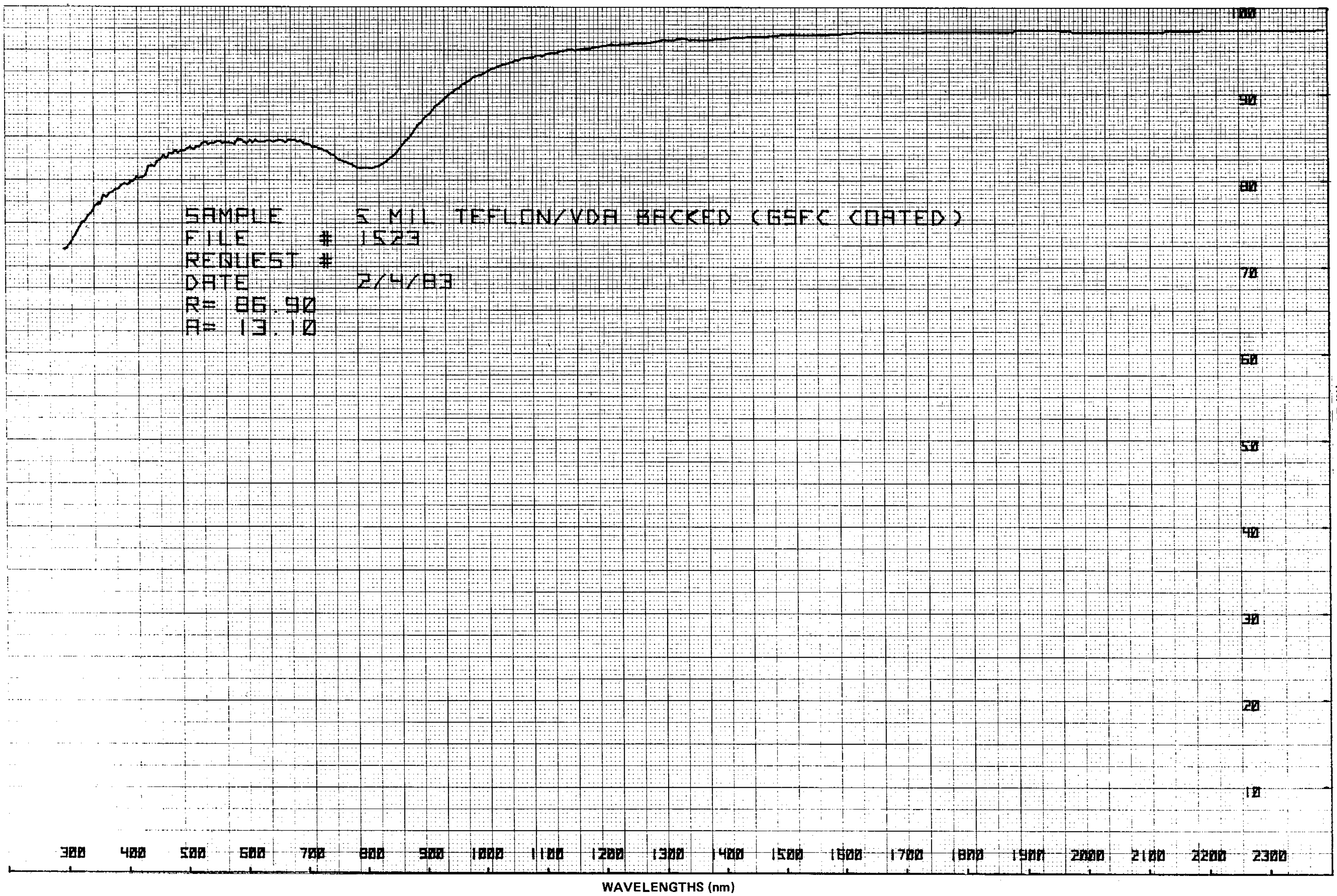

Figure 16. 5-Mil Teflon/VDA Backed (GSFC Coated).

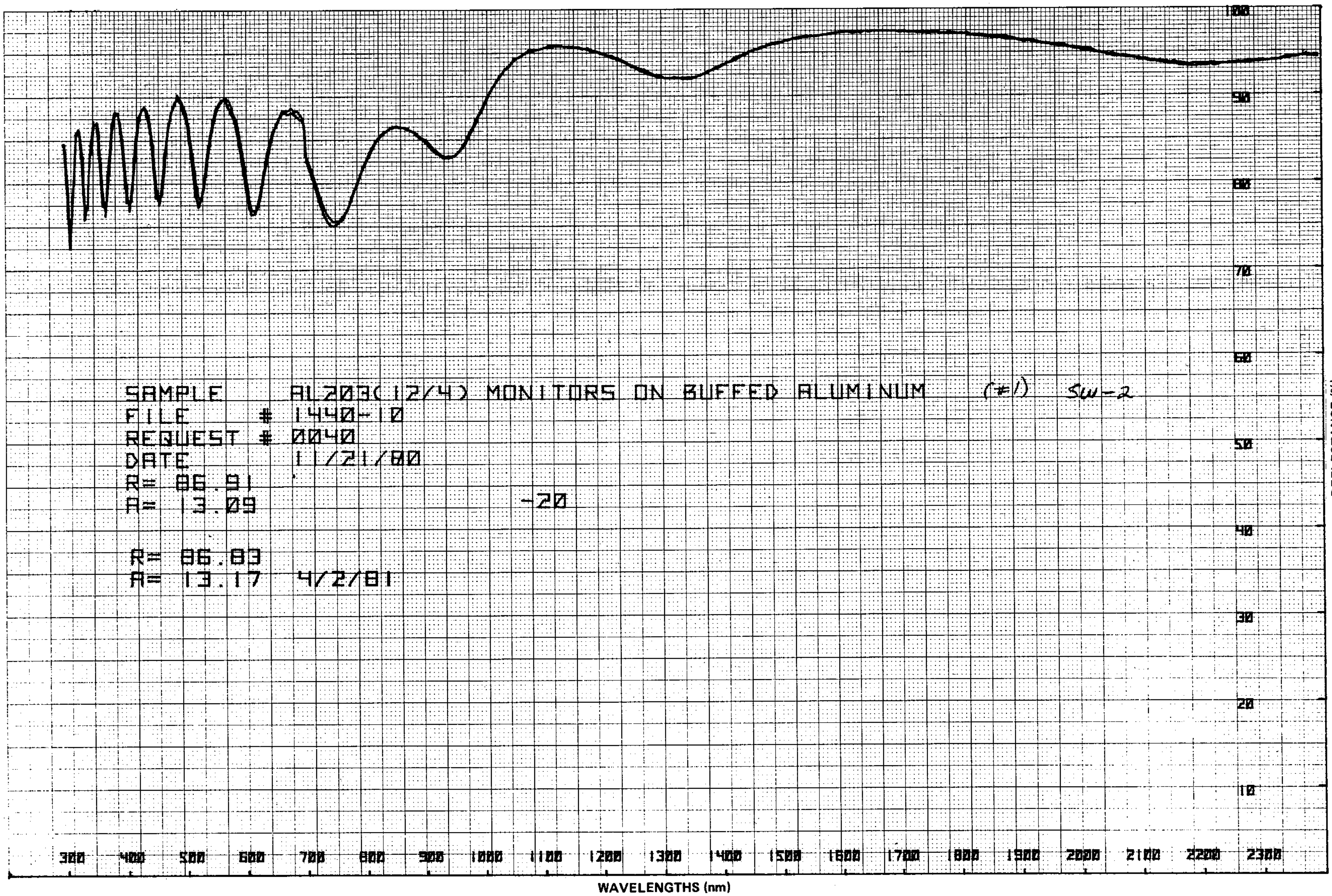

Figure 17. $A1_2O_3$ (12/4) Monitors on Buffed Aluminum.

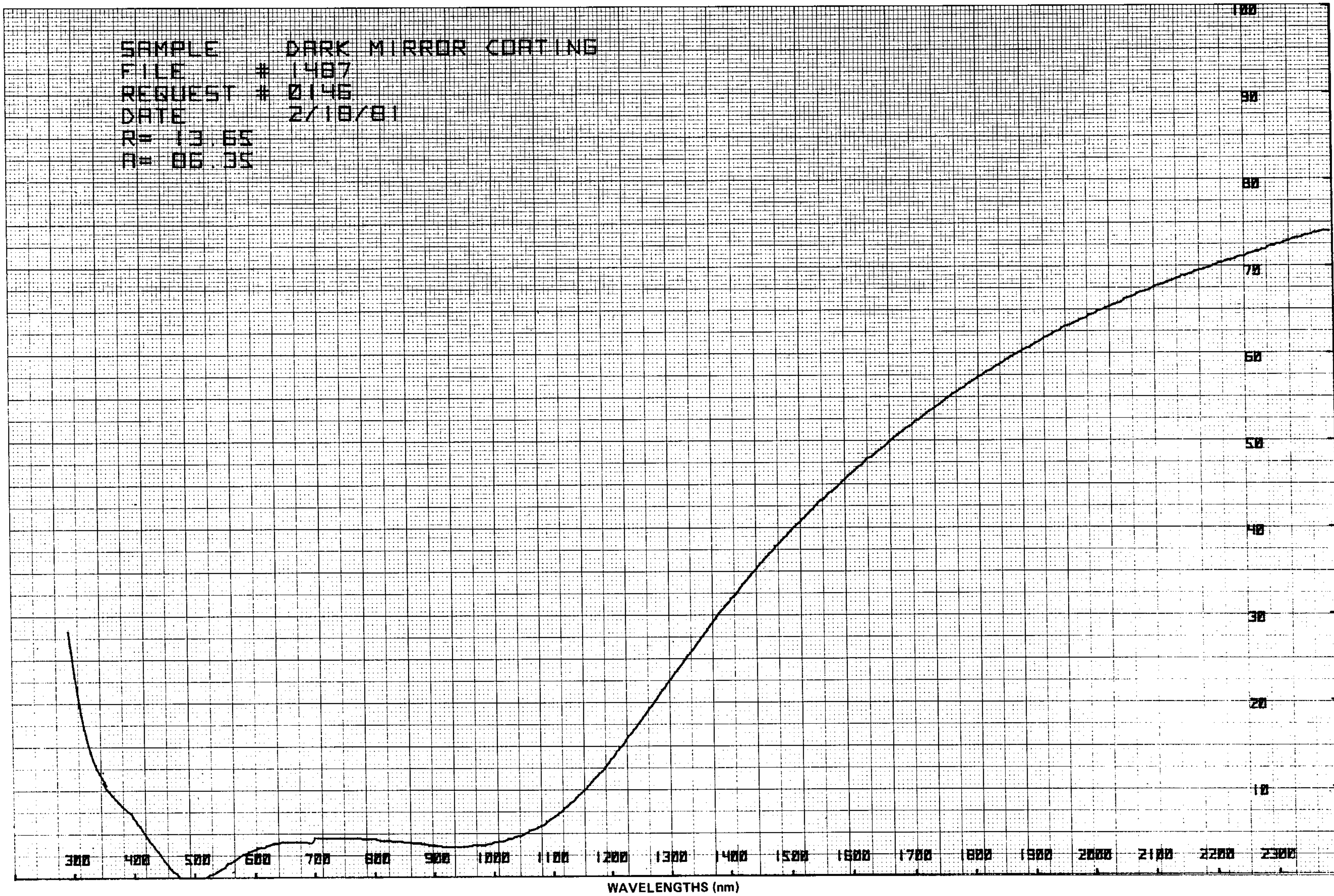

Figure 18. Dark Mirror Coating.

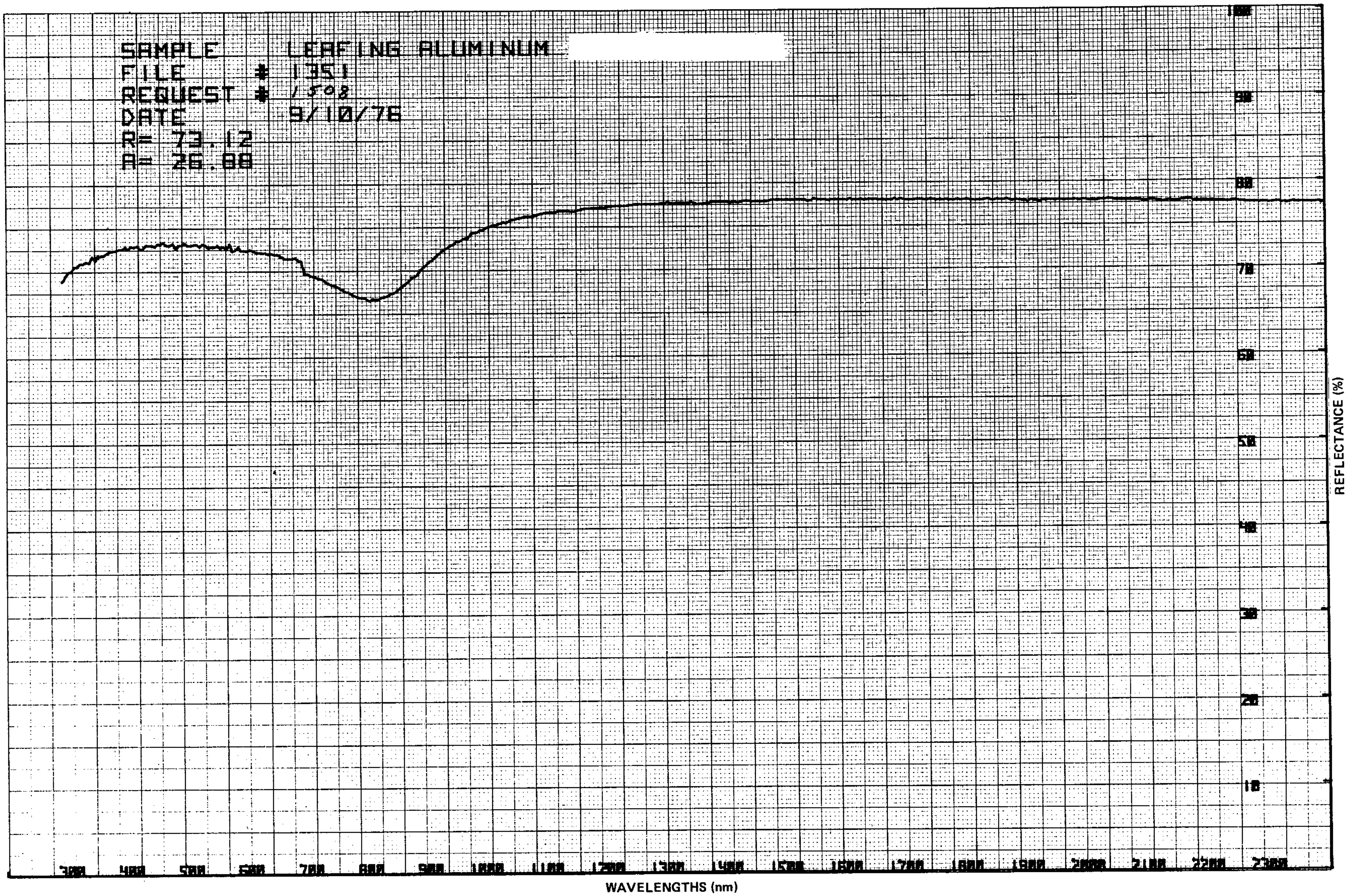

Figure 19. Leafing Aluminum.

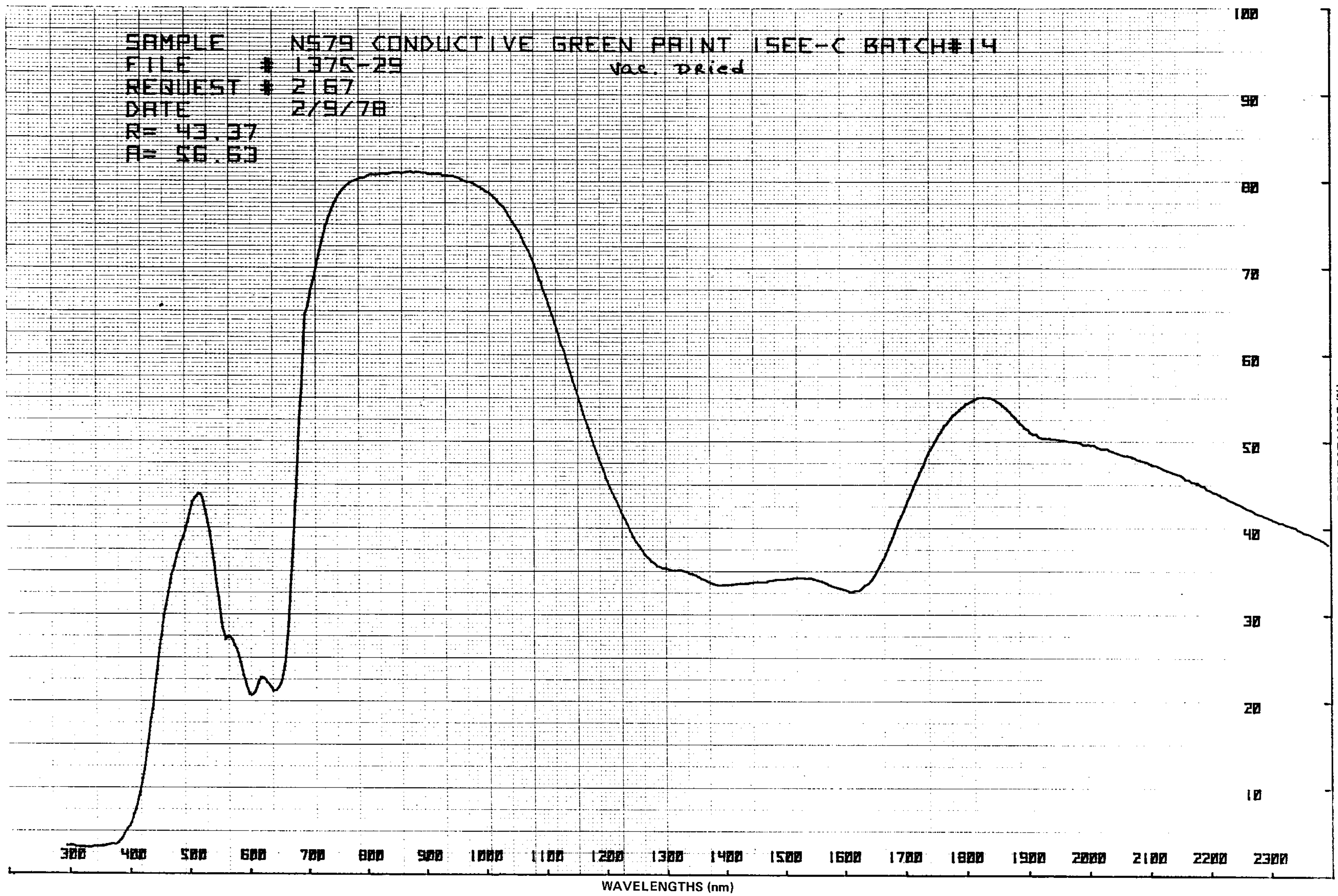

Figure 20. NS79 Conductive Green Paint.

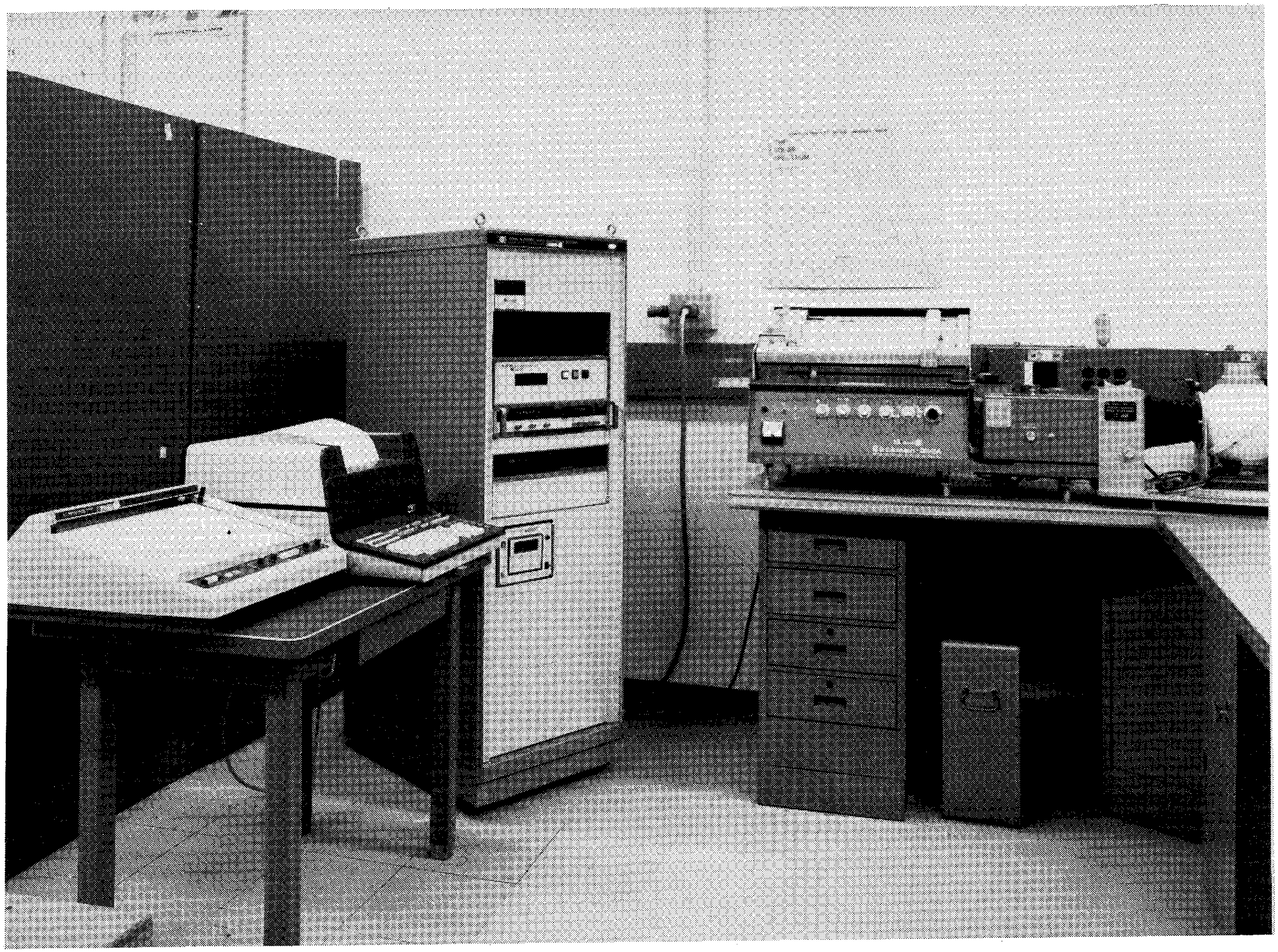

Figure 21. Solar absorptance facility.

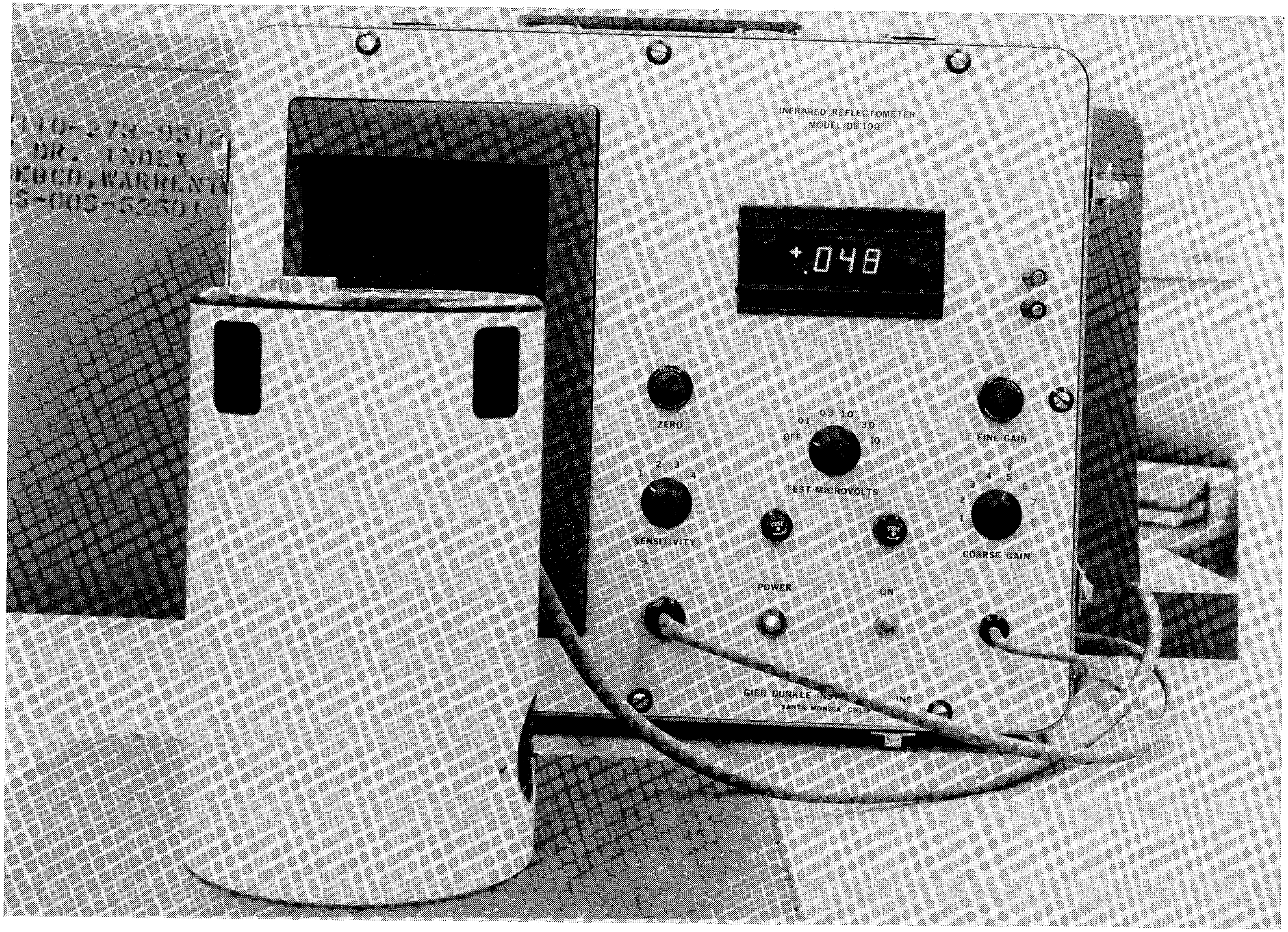

Figure 22. DB100 portable emissometer.

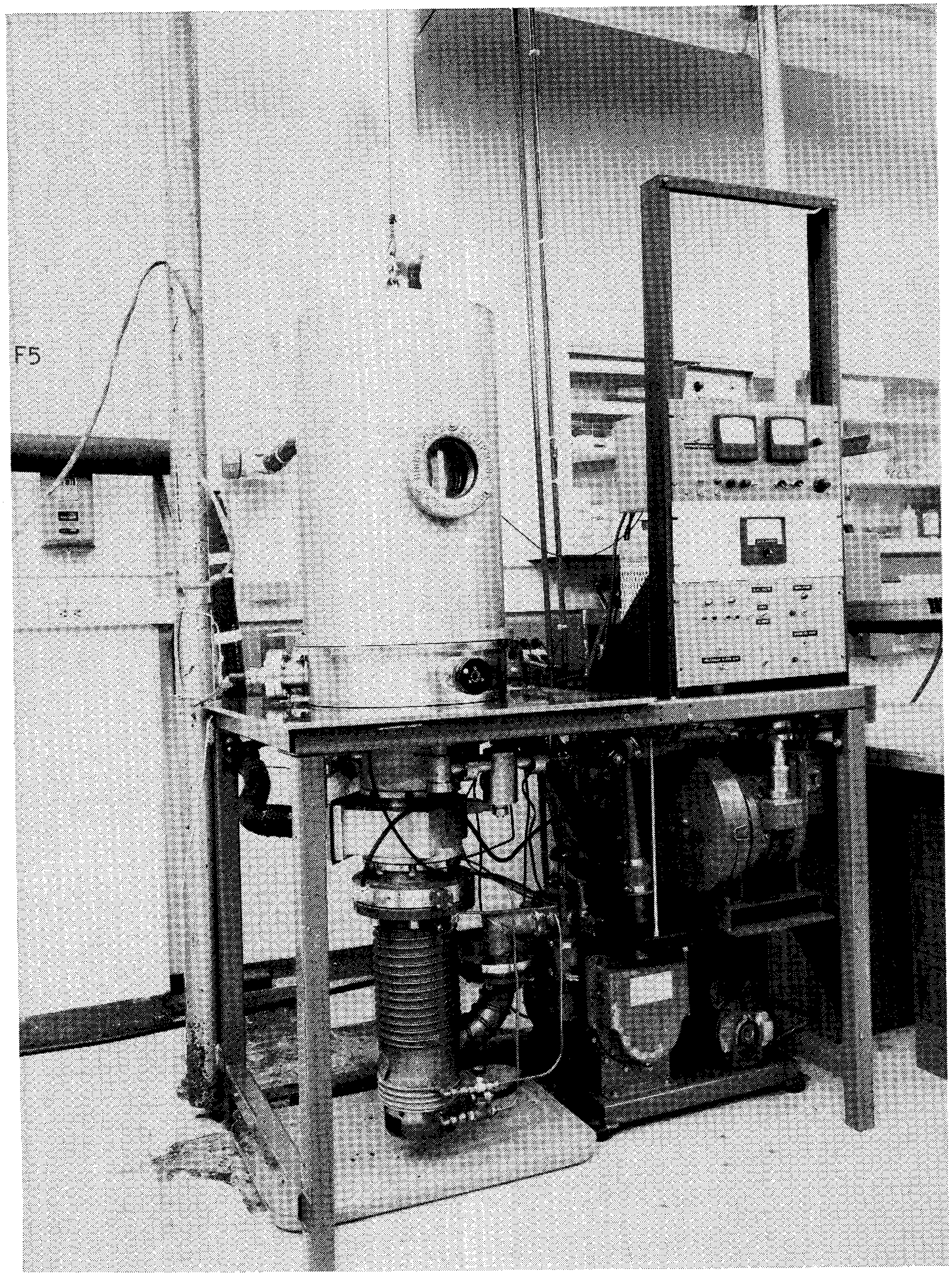

Figure 23. Hemispherical emittance facility.

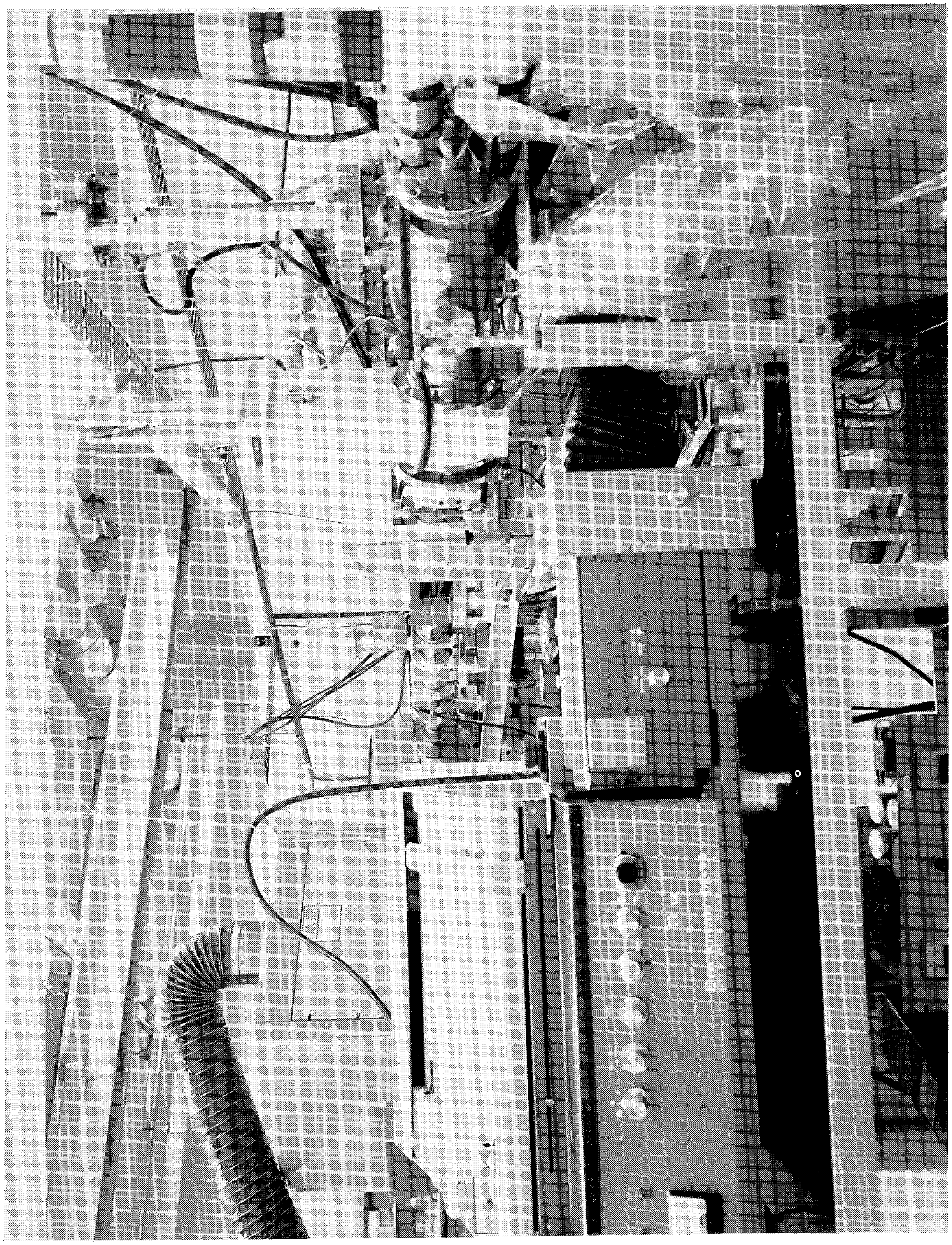

Figure 24. Solar-wind facility.

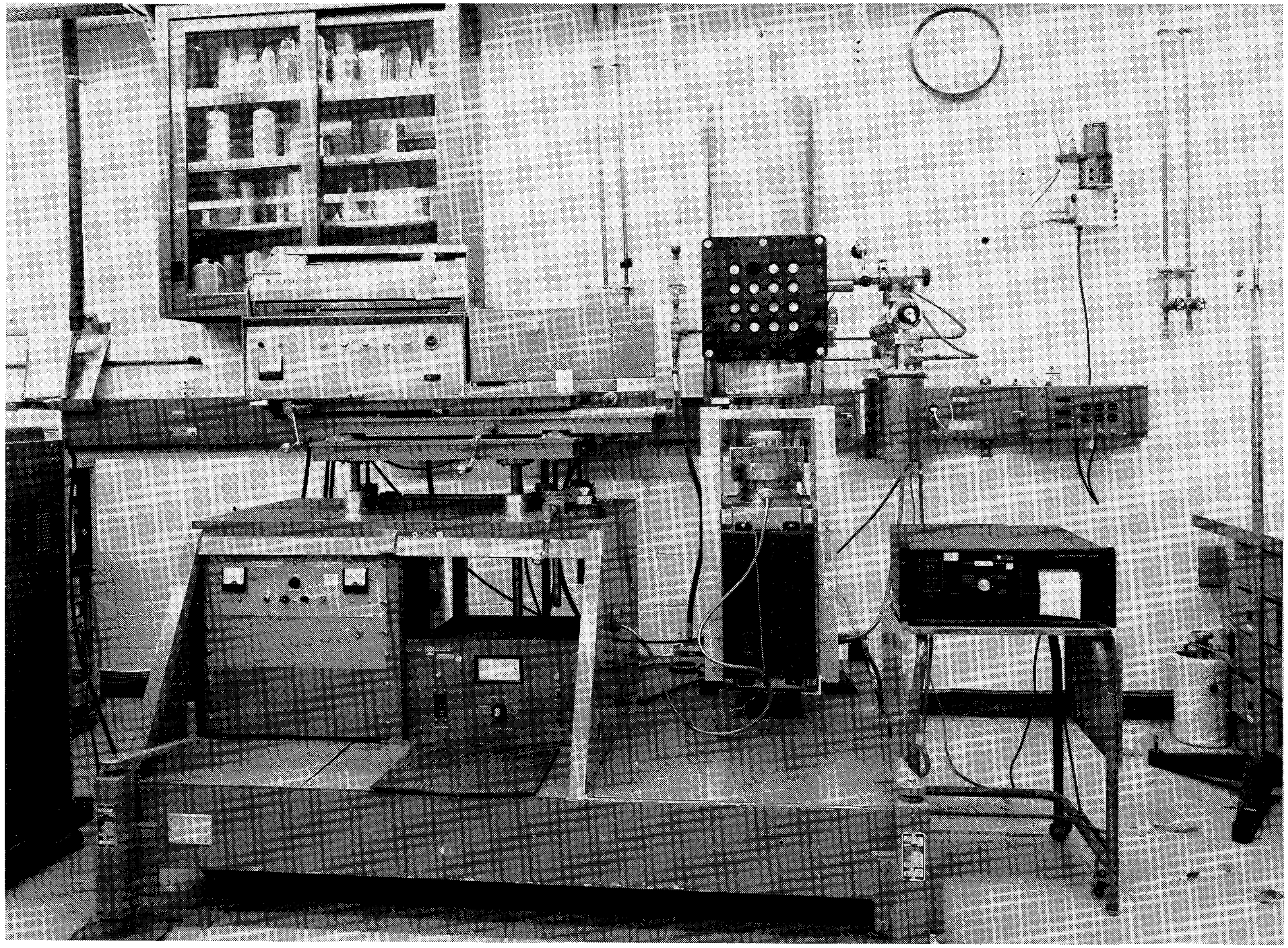

Figure 25. Multisedes system (multisample degradation facility).

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15. Supplementary Notes

16. Abstract

Solar absorptance and thermal emittance of spacecraft materials are critical parameters in determining spacecraft temperature control. Because thickness, surface preparation, coatings formulation, manufacturing techniques, etc. affect these parameters, it is usually necessary to measure the absorptance and emittance of materials before they are used. Also, because most materials exhibit some amount of degradation due to outgassing, ultraviolet, and/or particle damage, it is necessary to conduct laboratory testing on these materials before certifying them for use in space.

This document contains absorptance and emittance data for many common types of thermal-control coatings, together with some sample spectral data curves of absorptance. In some cases for which ultraviolet and particle radiation data are available, the degraded absorptance and emittance values are also listed.

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